TISA Update - Terra Gridded Monthly Data

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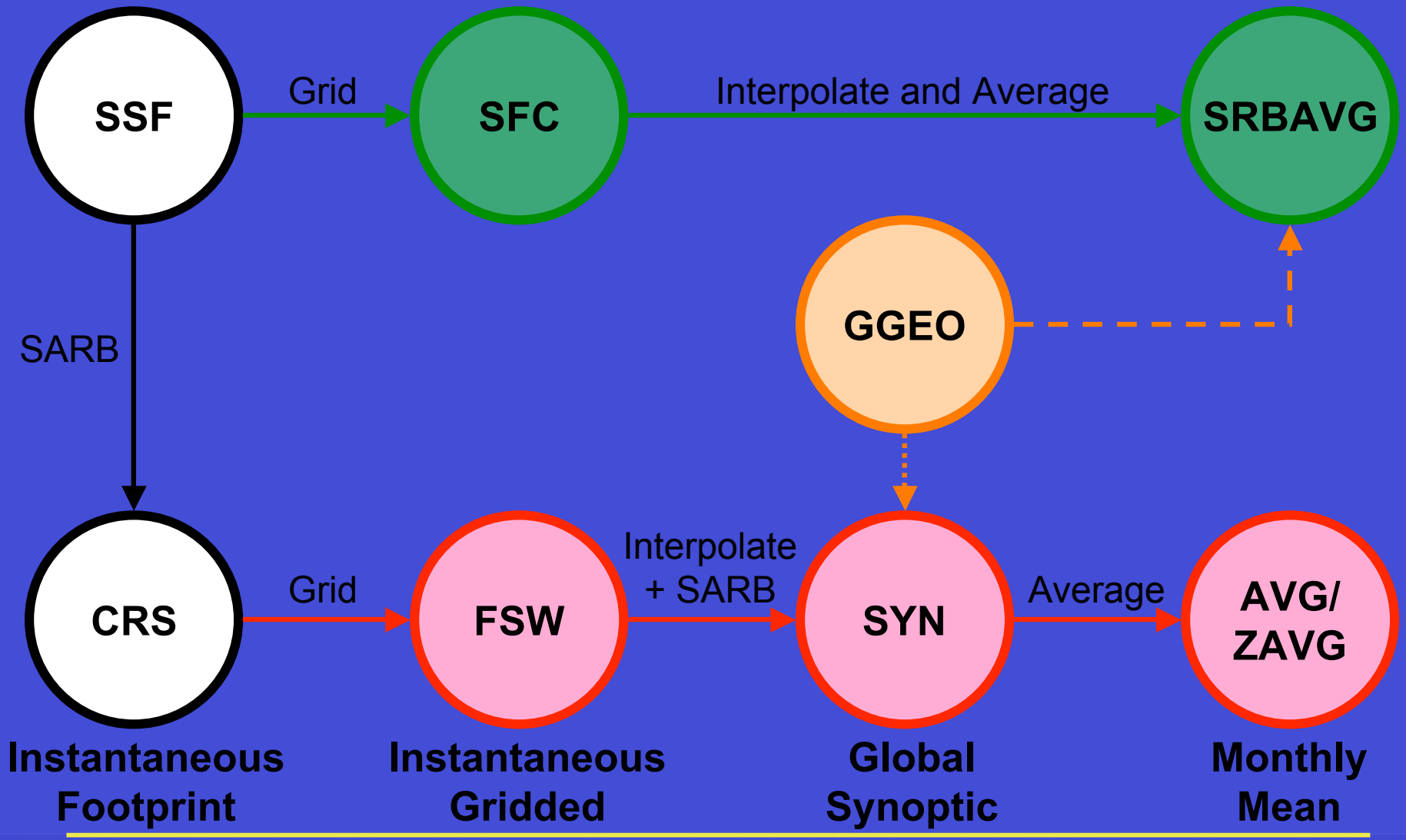
Second CERES-II Science Team Meeting
Williamsburg, VA
November 2 - 4, 2004

Outline

- TISA product status
- Progress since last meeting
  - Changes in data collection
  - Calibration improvements
  - Algorithm development
  - Validation results
- Major issues
- Planned future work

CERES Advanced TISA Processing



TISA Product Update: SFC

- Spatially averaged product on 1° x 1° global grid
  - Derived from SSF (CERES footprint data)
- SFC Edition 2B in production and scheduled for release
  - Data Quality Summary delivered
  - SFC now include MODIS aerosols
  - Minor error on SFC
    - Hourbox index incorrect for final 12 hours of month
    - Will be corrected in next edition (2C)
- 3 Years of Terra Edition 2C scheduled for release in December

TISA Product Update: FSW

- Spatially averaged product on 1° x 1° global grid
  - Derived from CRS (CERES footprint data + SARB)
- FSW Edition 2B in production
  - Data Quality Summary delivered
  - Product will be released following CRS approval
  - A few missing parameters on FSW
    - Will be added to future editions

TISA Product Update: SRBAVG

- Spatially/Temporally averaged product on 1° x 1° global grid
  - Monthly mean TOA and surface fluxes + cloud data
- SRBAVG validation product produced
  - GEO LW included. GEO SW set to default
  - 2 years of Terra data available
  - Surface fluxes provided to Stackhouse for SRB comparison
  - Months with <31 days include large spatial gaps
    - Problem tracked down and will be corrected on Edition 2C
- 3 years of Terra Edition 2C scheduled for release in December

TISA Product Update: SYN/AVG

- Spatially/Temporally averaged product on 1° x 1° global grid
  - 3-hourly TOA, atmospheric, and surface fluxes + cloud data
- SYN/AVG Beta 2 delivered for testing
  - Beta at DAAC (Terra only)
  - Not the latest version of interpolation
  - Mainly used to test logistics
  - Final product will incorporate latest NB-BB and normalization algorithms developed for SRBAVG

Progress Since Spring Meeting

- Calibration completed through Spring 2004
  - Initial calibrations for GOES-12, GOES-9, MET-8
  - Refined Deep Convective Cloud Calibration (DCCC)
    - Working with Stackhouse on extending to ISCCP
- Major improvements in SW NB-BB algorithm
  - Details later in presentation
- McIdas delivered to DAAC
  - Testing underway
  - Will be collecting 1-hourly, 3-channel data (use with Flashflux)
- SFC, FSW, SARBAVG Edition 2B delivered
  - Edition 2C scheduled for release in December

McIDAS GEO Data Acquisition

- Currently we get GEO data from several sources
  - Data is 3 hourly
  - Different formats for each satellite
  - Data gaps and poor navigation are common
  - New satellites require sources with new code
- Use McIDAS (Man computer Interactive Data Access System) to acquire GEO data
- McIDAS is a set of tools to acquire, manage, analyze, display, and integrate data
  - developed by Univ. Wisc-Madison's SSEC

McIDAS GEO Data Acquisition

- McIDAS GEO data provides these benefits
  - All GEO satellites available, MET-8, MET-5, GMS-5, GOES-10, GOES-12
  - Standardized formats
  - Provides new code for reading new GEO satellites (i.e. SEVERI)
  - Data collected in near Real-time
  - Solves navigation problems (i.e. GMS5)
  - Access to historical data - Eliminates data gaps
  - Improved calibration information
- Collecting 1-hourly, 8km resolution, 3-channel data
  - use with Flashflux

McIDAS GEO Data Acquisition

- Current Status of McIDAS GEO data
  - Operational data collecting scripts for GOES-12, GOES-10, GOES-9, MET-5, & MET-8 completed
  - McIDAS hourly data is currently being collected for all 5 GEO satellites since June 2004 (L. Nguyen)
  - Operational data collecting to be turned over to the Langley DAAC
    - Testing phase by November 12, 2004
    - Operational by end of 2004
- Historical McIDAS GEO data needed to replace non-McIDAS data
  - Langley DAAC to order and archive data from Jan-Aug 1998 and Mar 2000 through May 2004

McIDAS GEO Data Implementation

- Developed the software to integrate Mcidas format into TISA GGEO code
  - Tested one day of images for each GEO satellite
  - New GEO quality control technique ready for future delivery
  - New web site for GEO data QC
- Soon to test run the Mcidas GGEO data with the 3 channel cloud algorithm
  - Test September 2004

Algorithm Development

Implementation of GEO measurements

- Calibrate GEO visible radiances against MODIS
  - Operational GEO visible radiances are not calibrated and degrade over time
  - GEO IR radiances have onboard calibration
- Convert GEO narrowband radiances to broadband radiances
- Apply CERES bidirectional and directional models to convert radiances into fluxes
  - Requires consistent scene identification between imagers and GEO
- Normalize GEO derived fluxes with CERES fluxes
  - Place IR GEO diurnal shapes onto CERES OLR

Geostationary visible calibration methods

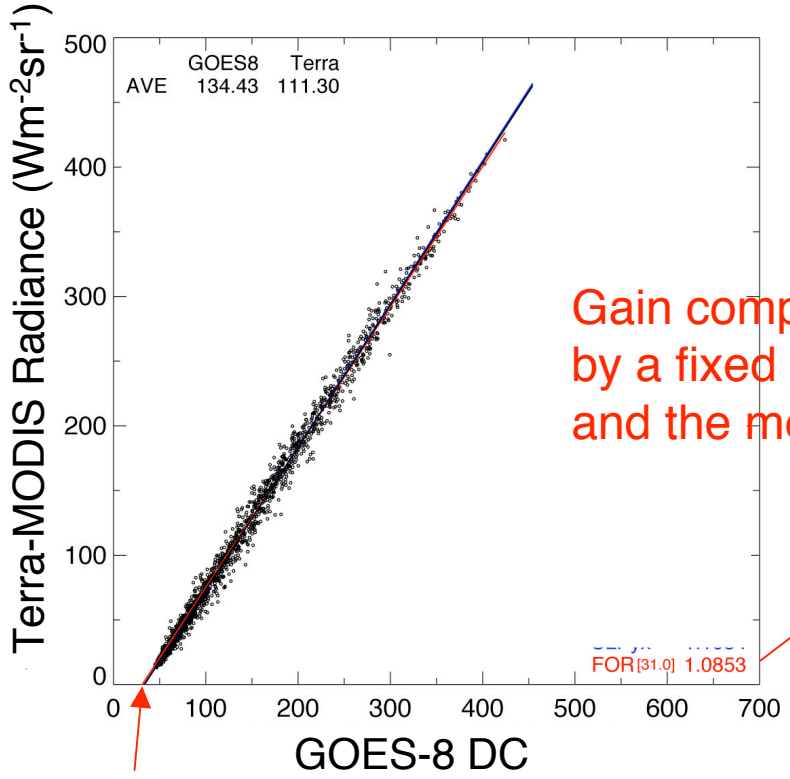
- Calibrate GEO against MODIS using ray-matching technique
- Cross-calibrate adjoining GEO satellites
  - Do they validate the MODIS calibrations?
- Validate using deep convective cloud technique
  - Bright predictable targets, easily identified
- Monitor GEO derived cloud properties against MODIS over time
  - Changes in cloud properties indicate calibration drift

MODIS and GEO ray-matching technique to transfer calibration

- Match coincident, co-located, co-angled radiances
  - Bin visible pixel level radiances into 1.0° latitude by longitude regions (near GEO sub-satellite point)
  - Time match within 15 minutes
  - Restrain angles to $\Delta vza < 5°$, $\Delta raz < 15°$, $\Delta sza < 5°$
- Normalize solar constants and cosine solar zenith angles

GOES-8 vs Terra-MODIS

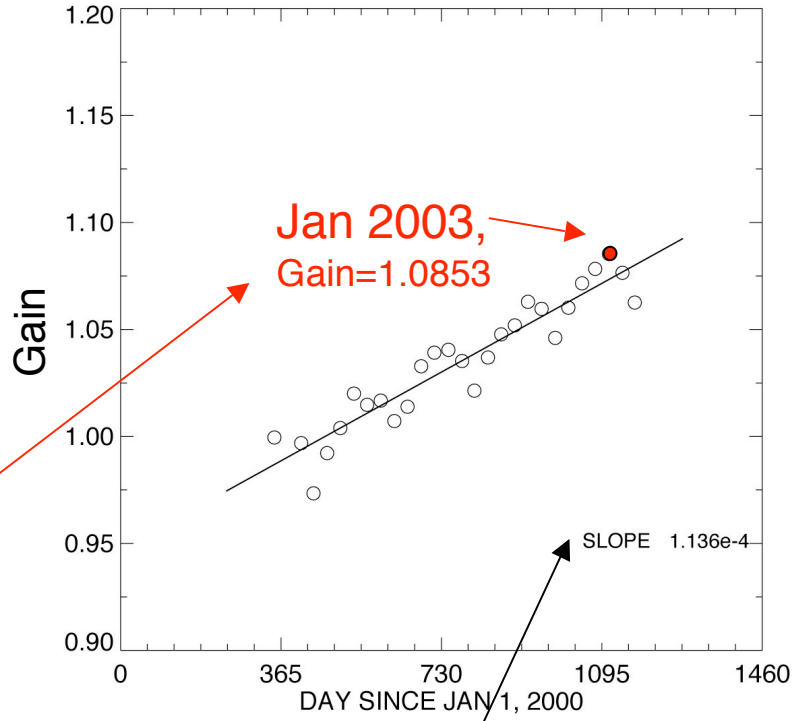
January 2003, Monthly Plot



Offset based on deep space look

Gain computed by a fixed offset and the mean

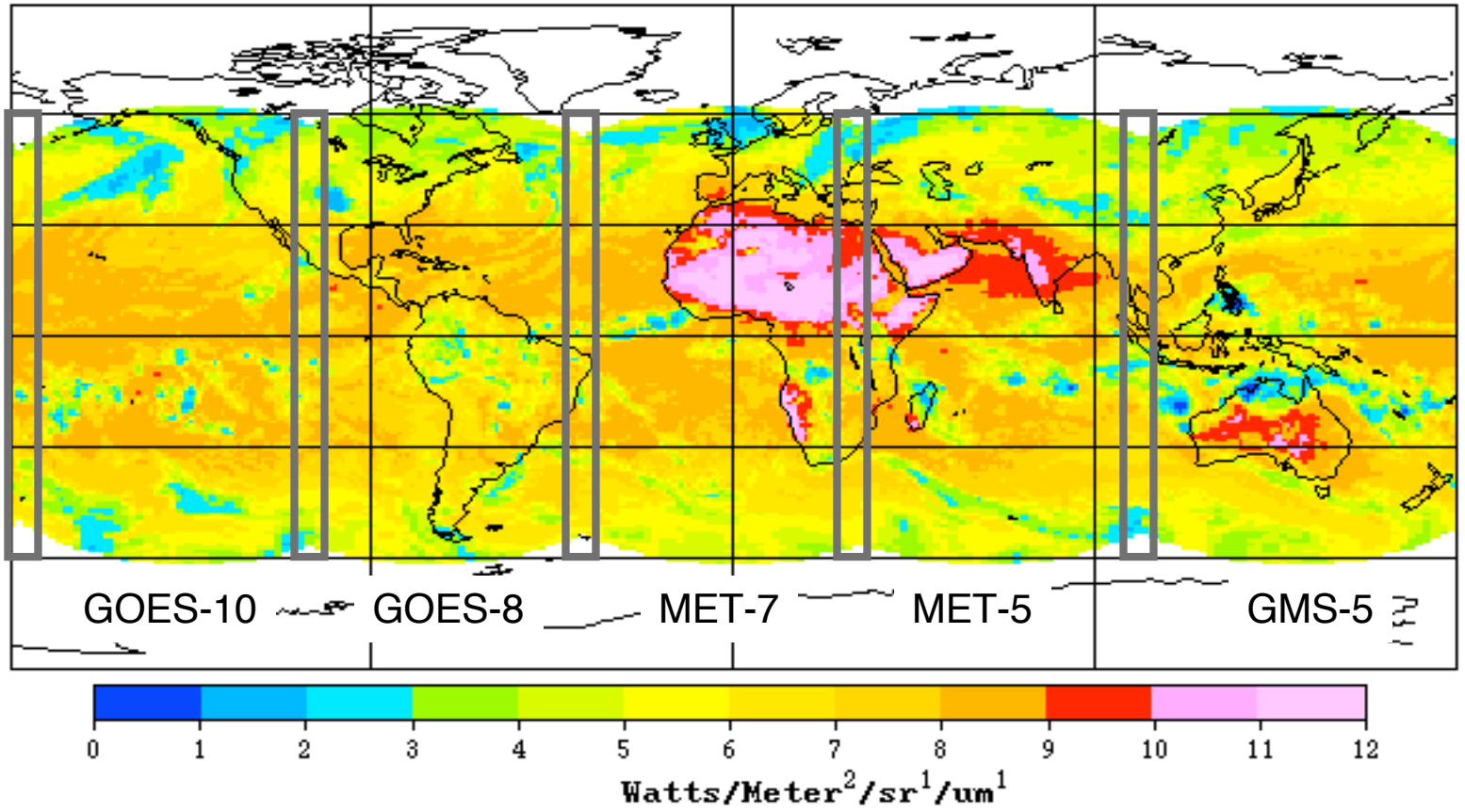
Timeline



Degradation rate = 365*1.136e-4 = 4.15%/year

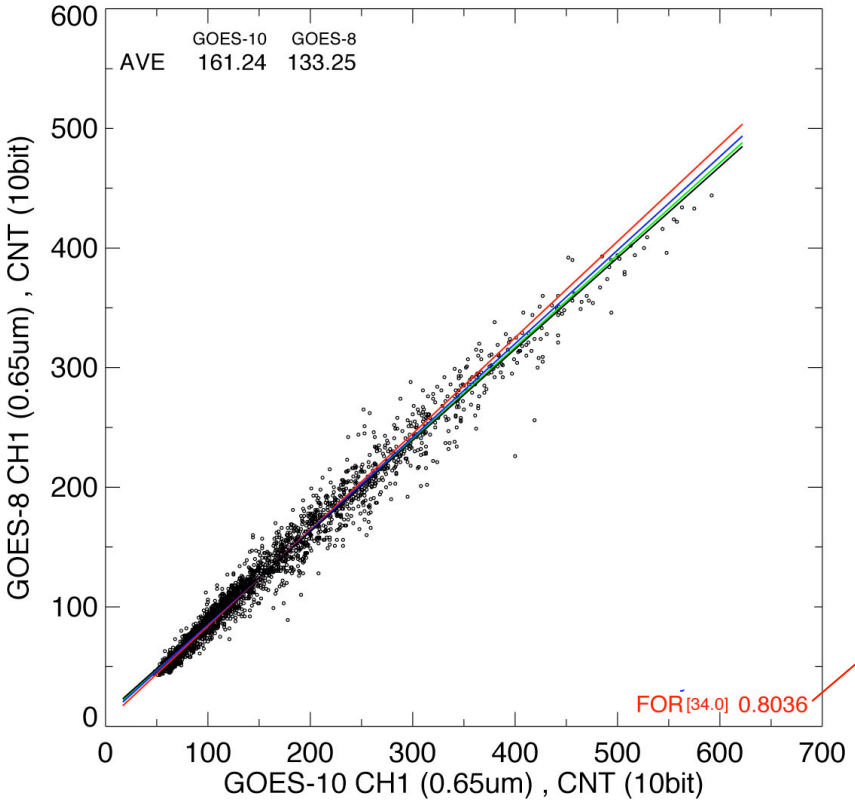
GEO noon cross-calibration regions

- GEO bisecting longitude at solar noon ensures matched SZA, RAZ, and VZA

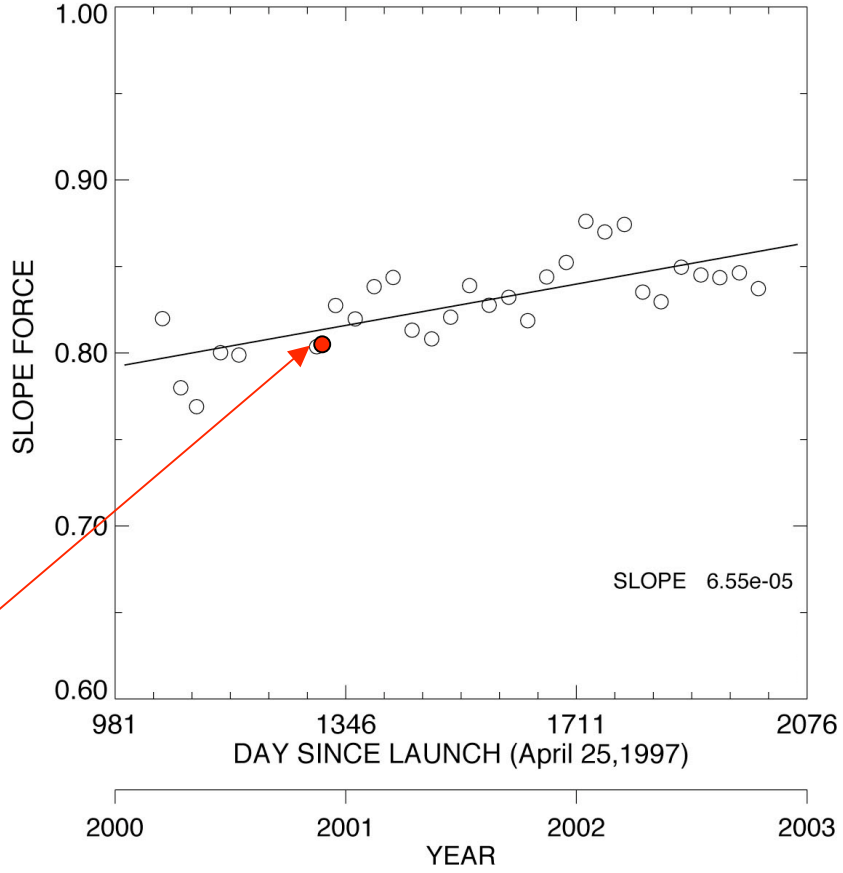


GOES-10 / GOES-8 noon cross-calibration

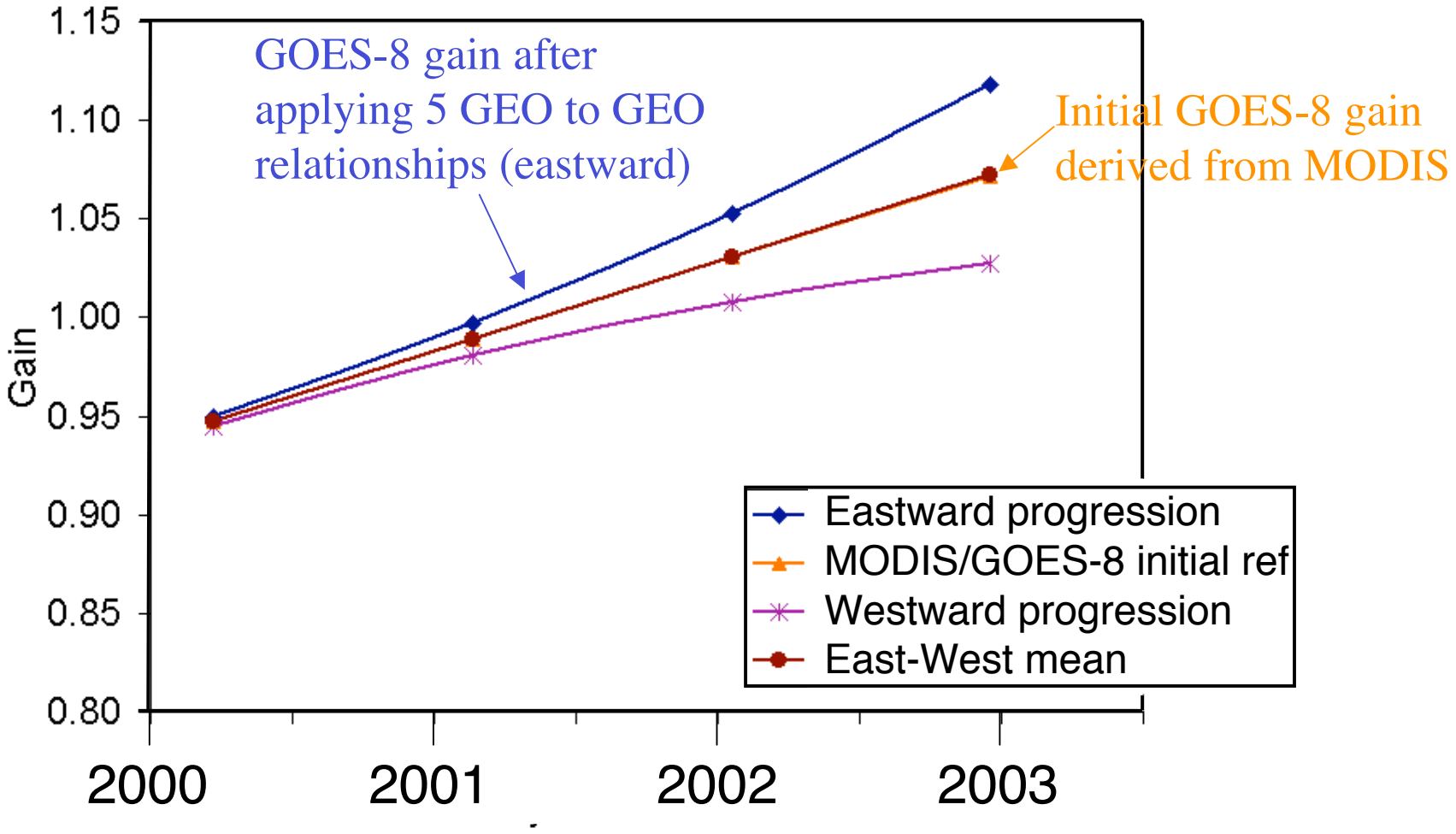
November 2000, Monthly Plot



Timeline



Geostationary noon cross calibration validation

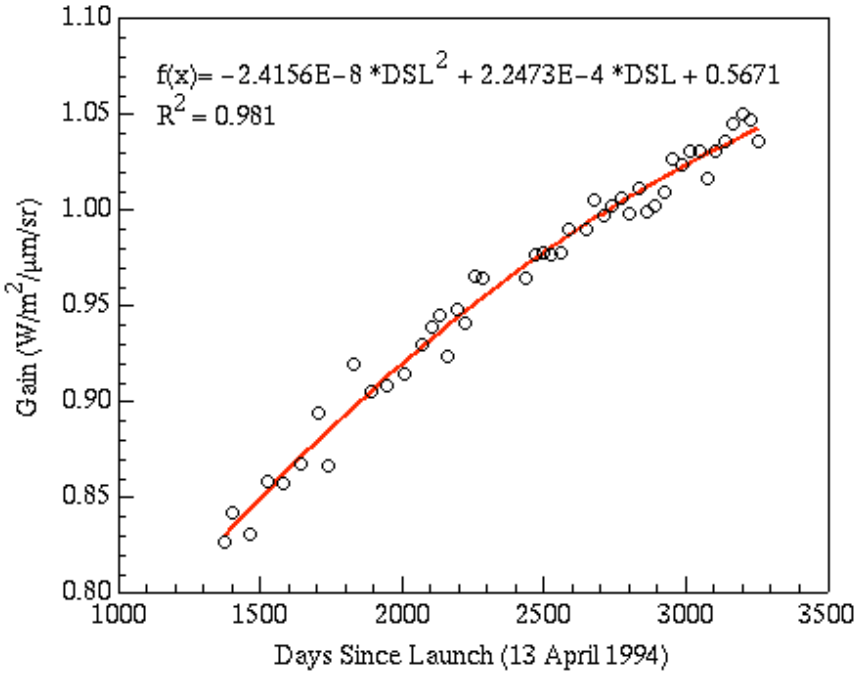


Progress in visible calibration

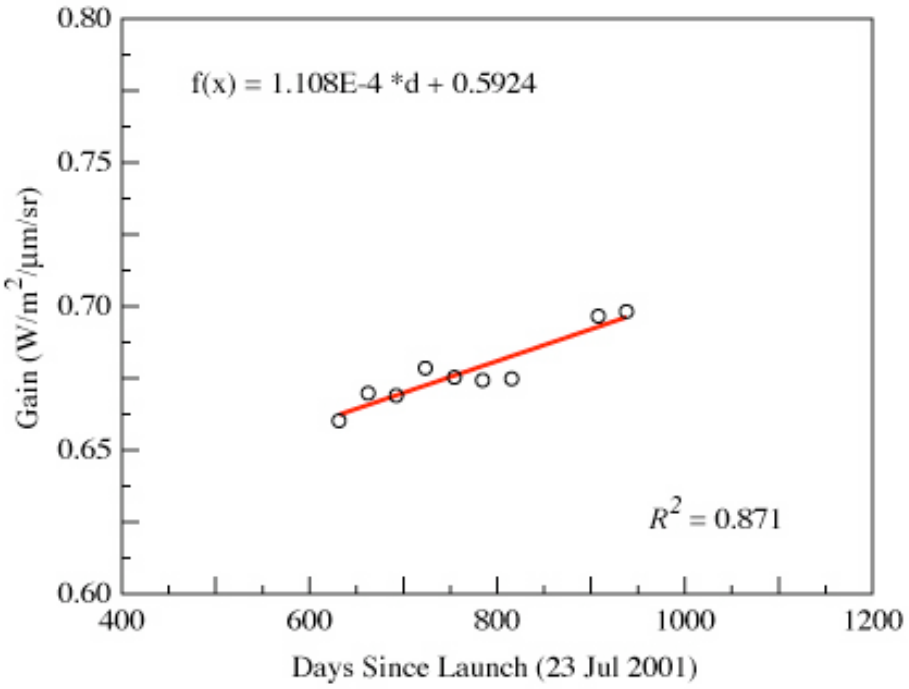
- GEO operational satellites have been updated
  - GOES-12 replaced GOES-8 in April 2003 (75° W)
  - GOES-9 replaced GMS-5 in May 2003 (140° E)
  - MET-8 replaced MET-7 in April 2004 (0° E)
- Noon cross-calibration when a GEO satellite replaced
  - GOES-8/GOES-12 vs GOES-10 example
- GOES-9 in use 1996-1998 and 2003 to present
  - How was the calibration effected
- Met-8 calibrations with Terra, Aqua and GOES-12
- Terra, Aqua and VIRS calibration comparisons

GOES-8 and GOES-12 trends based on VIRS

GOES-8 Trend Jan 1998 - Mar 2003

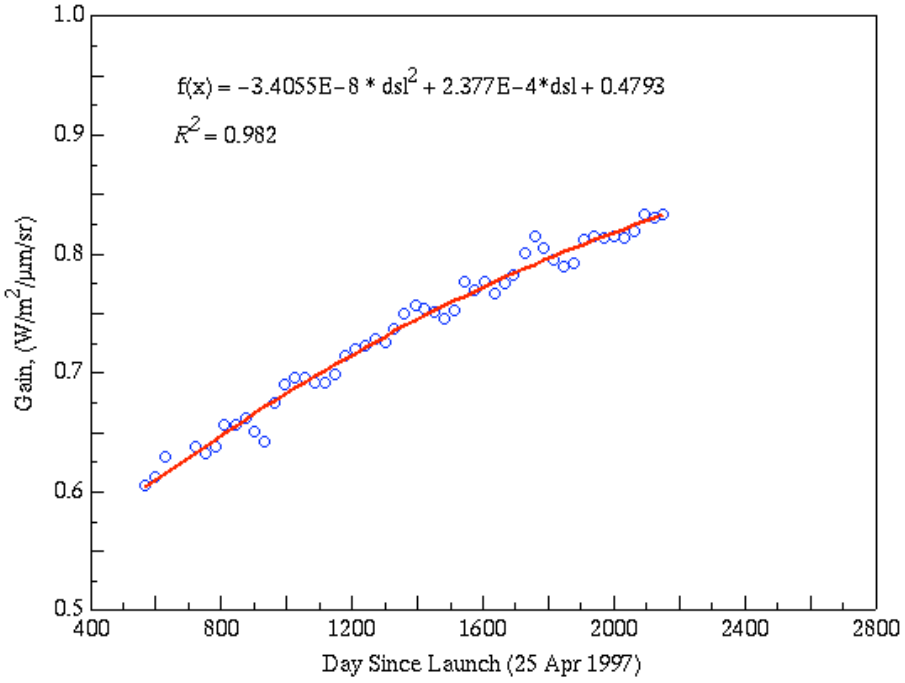


GOES-12 Trend Apr 2003 - Feb 2004

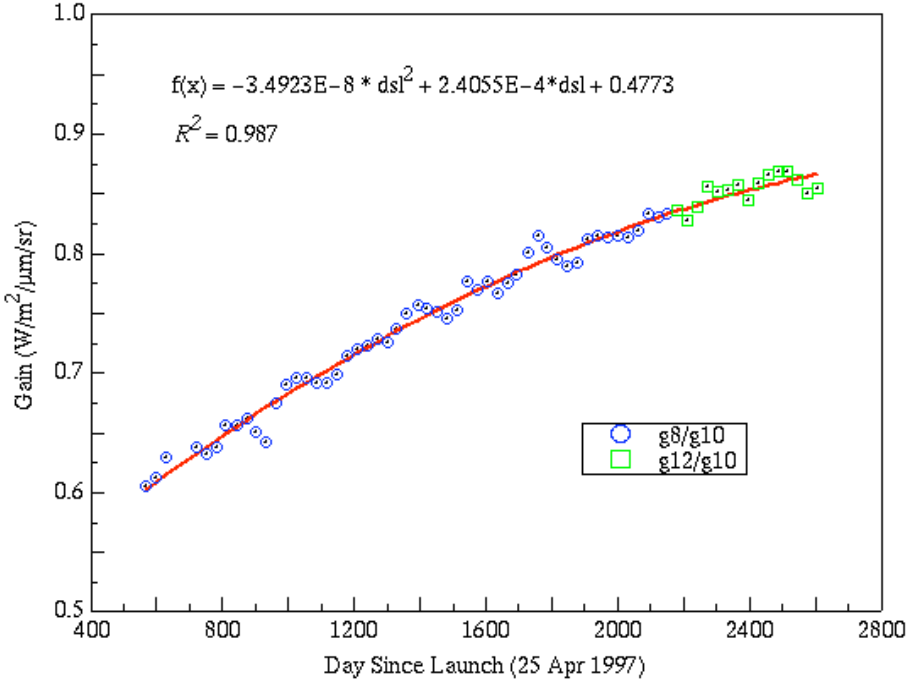


GOES-10/GOES-EAST Trend

GOES-10 slope trend using GOES-8
Nov 1998 - Mar 2003



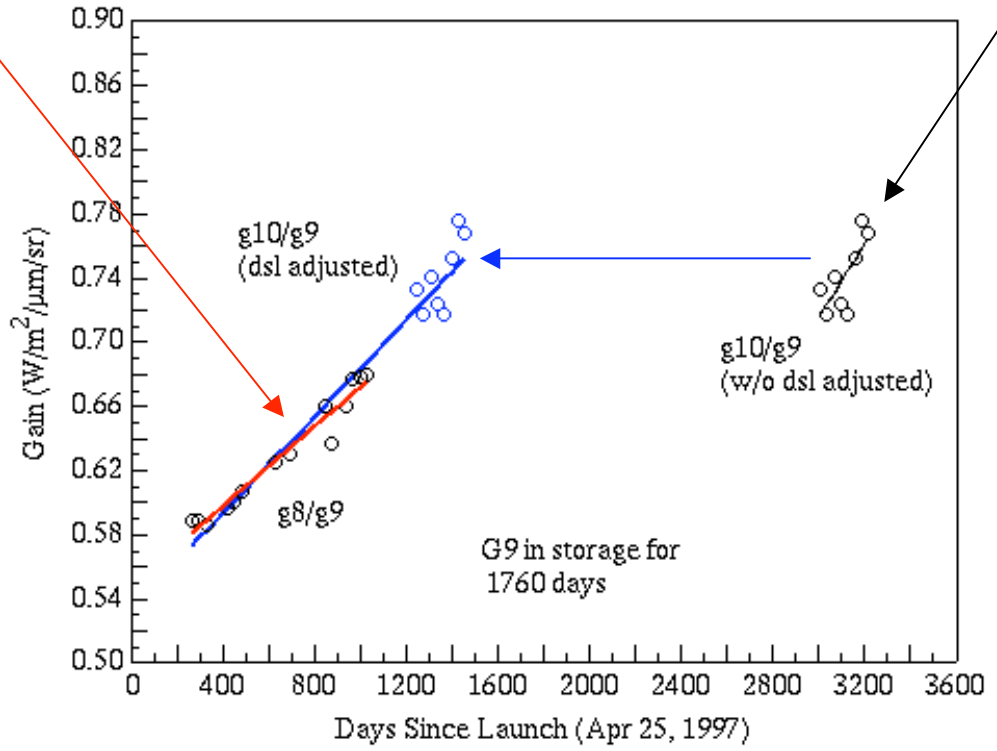
GOES-10 gain trend using GOES-12
Apr 2003 - Jun 2004



Trend of GOES-9

Subsat = 135° W
Using GOES-8/VIRS
data during 1996-1998

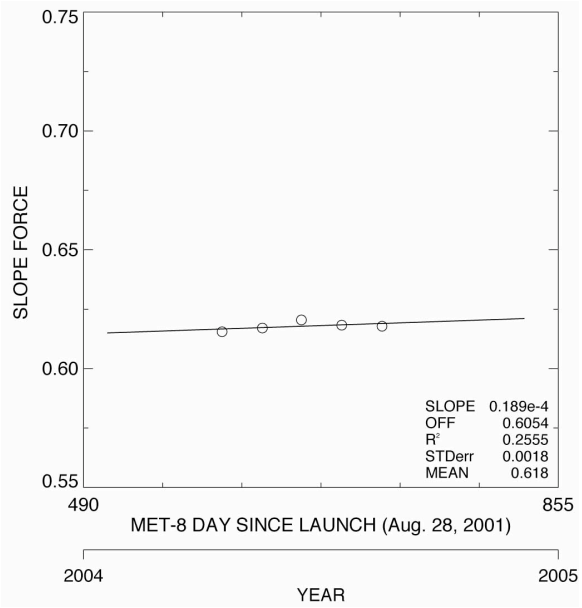
Subsat = 140° E
Using GOES-10/GOES-8/VIRS
data during 2003-2004



No degradation
during storage

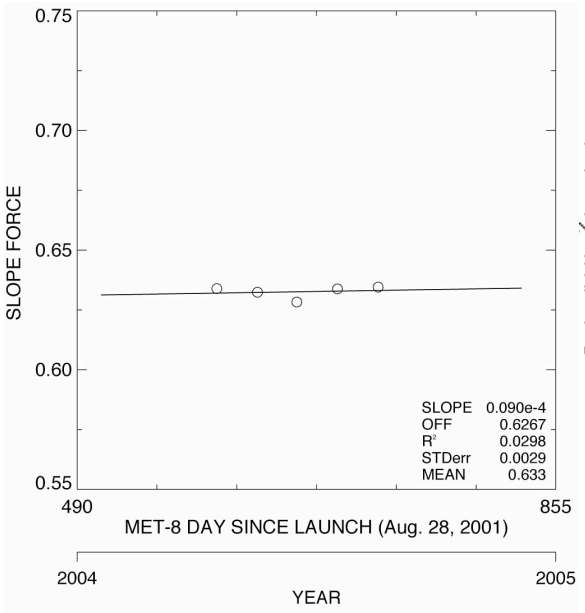
MET-8, visible trendlines

Terra-MODIS
April-August 2004



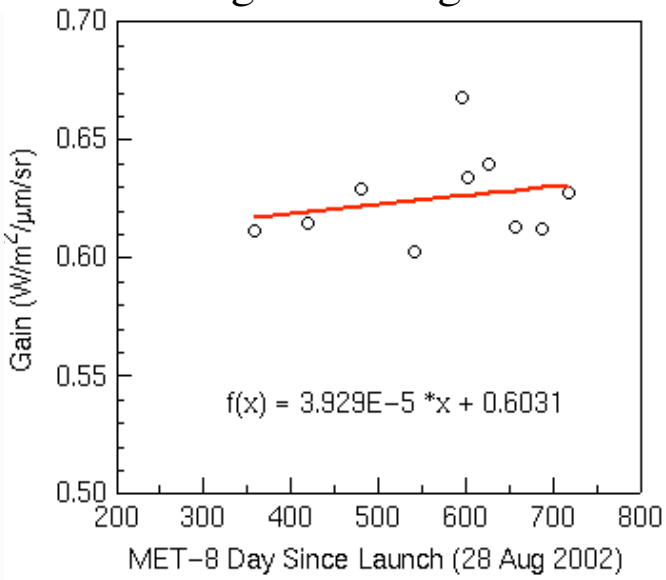
Gain 0.618

Aqua-MODIS
April-August 2004



Gain 0.633

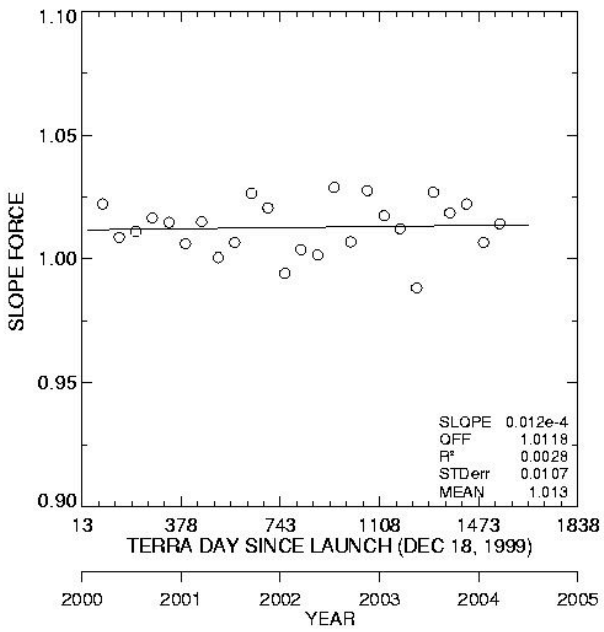
GOES-12/VIRS
Aug 2003-Aug 2004



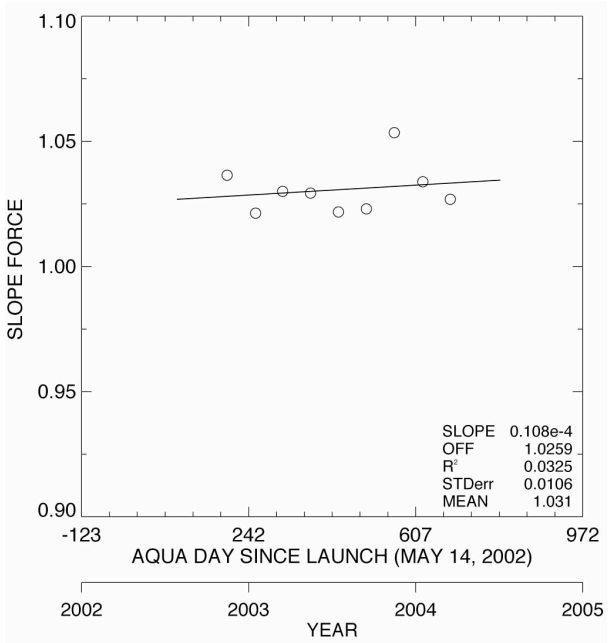
Gain 0.625

Reference Satellite Visible Inter-calibrations

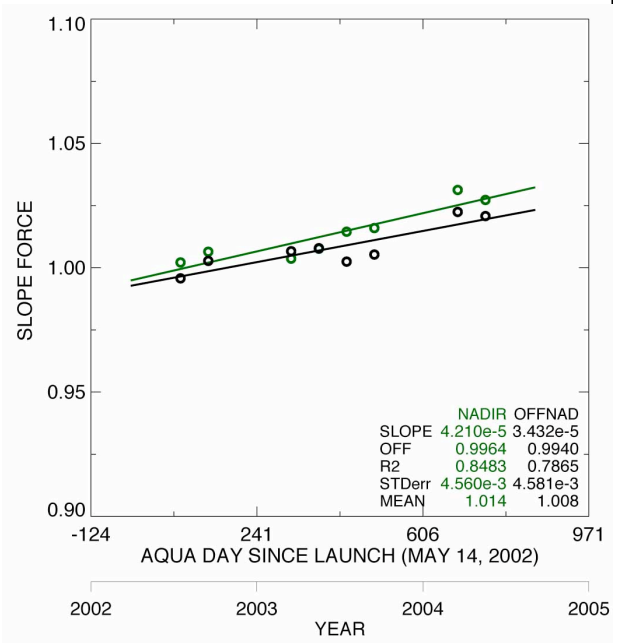
Terra/VIRS



Aqua/VIRS



Aqua/Terra



Gain 1.013 → $\frac{\text{VIRS}}{\text{Terra}}$ 0.987 * Gain 1.031 → $\frac{\text{Aqua}}{\text{VIRS}}$ 1.031 = $\frac{\text{Aqua}}{\text{Terra}}$ 1.018

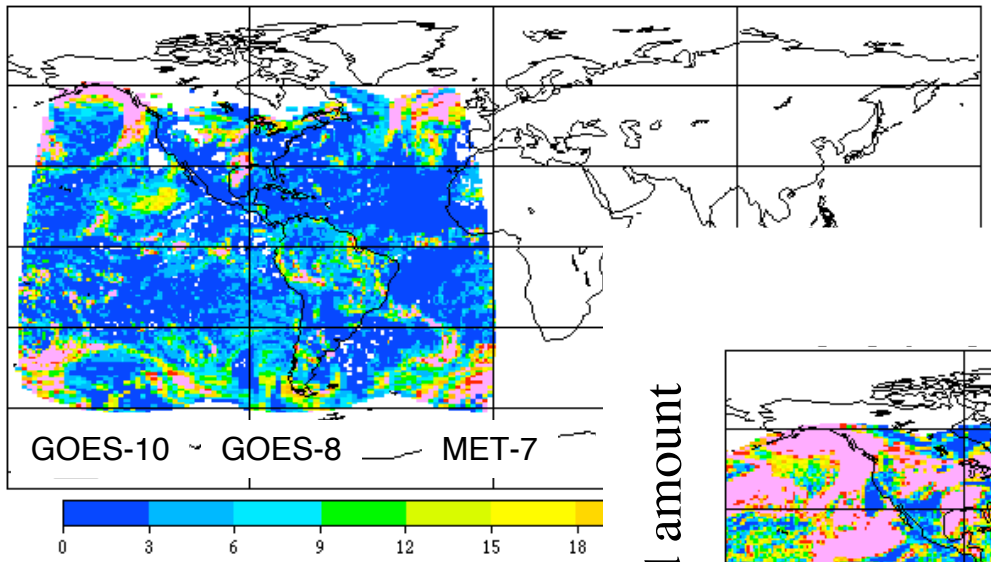
Gain 1.008 → From timeline 1.008 difference 1%

Monitor GEO cloud properties over time

- Generate MODIS equivalent cloud properties from GEO
  - Used for narrowband to broadband conversion
  - CERES bidirectional and directional models
- Compare GEO cloud properties against MODIS and check for stability
  - Cloud amount is based on visible and IR radiance thresholds
  - Changes in calibration are manifested by cloud amount drift

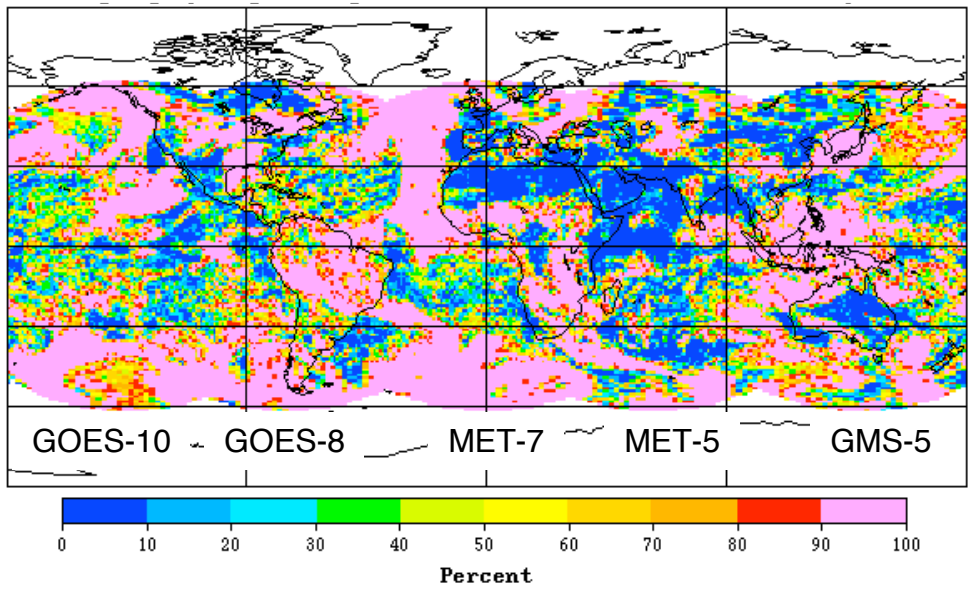
GEO derived cloud properties

Geo cloud optical depth

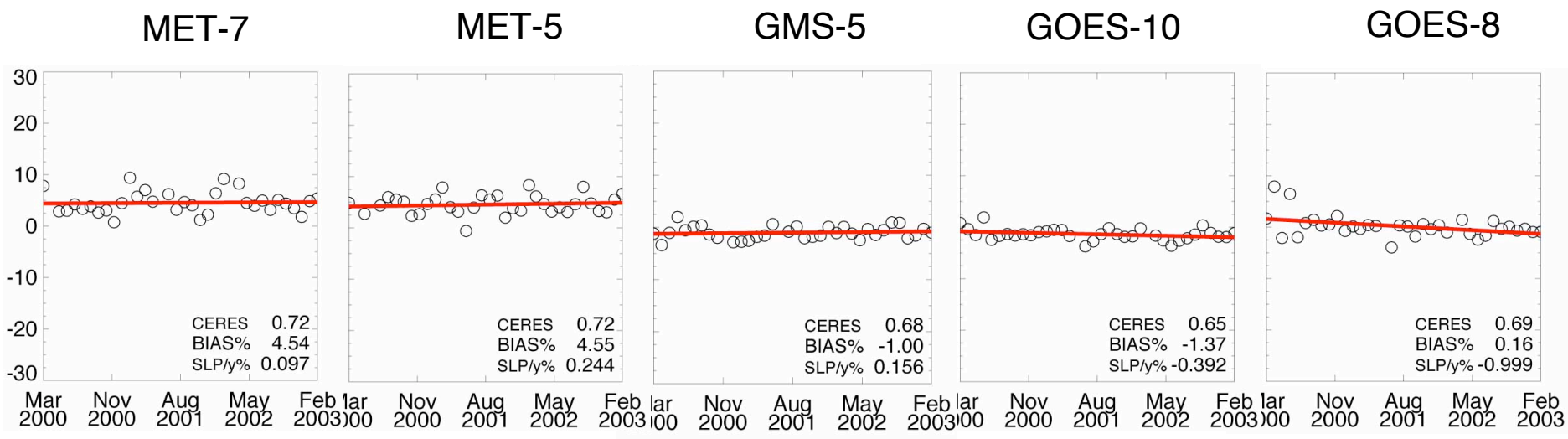


- March 15, 2000 18:00 GMT

Geo cloud amount

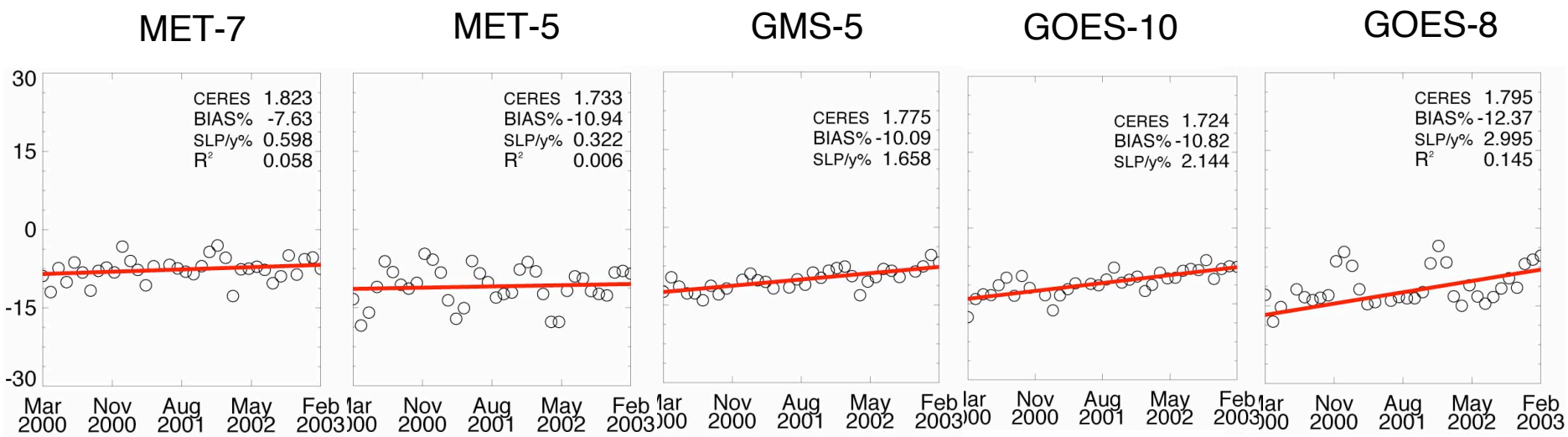


GEO - MODIS monthly mean cloud fractions



March 2000 - Feb 2003, OCEAN, (%) relative

GEO - MODIS monthly mean log optical depths

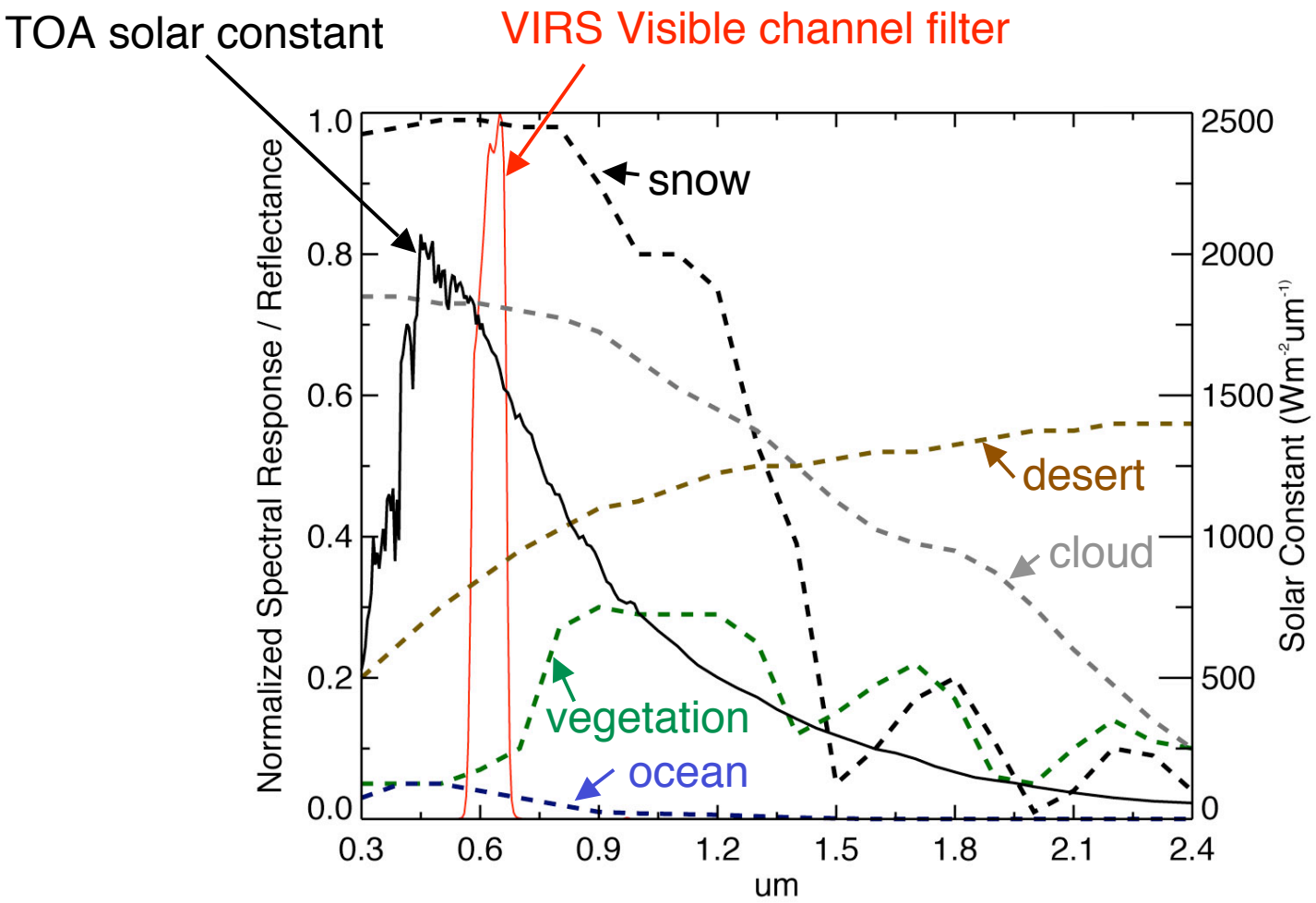


March 2000 - Feb 2003, OCEAN, (%) relative

Narrowband to Broadband (NB to BB)

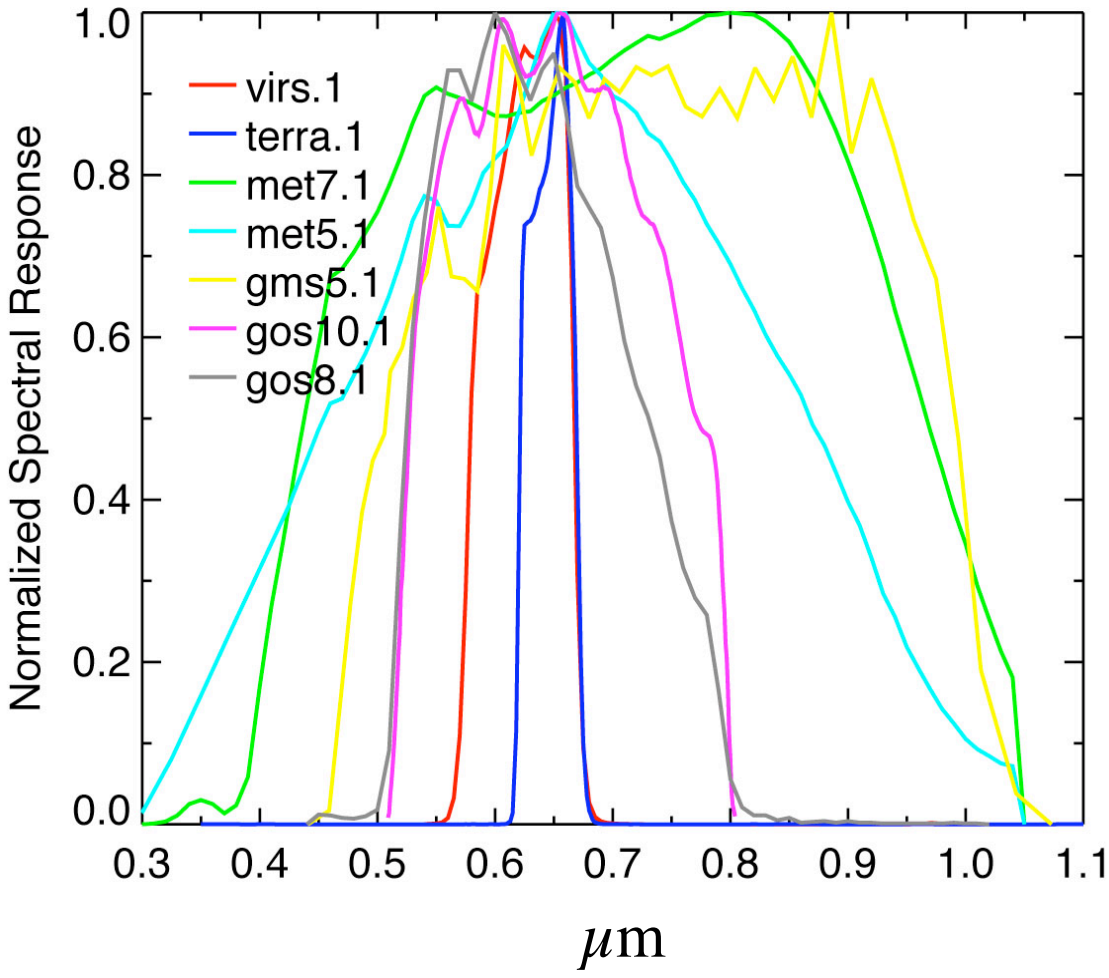
- Oceans, land, deserts and clouds (scenes) have wavelength and angular dependent reflections
- GEO visible filters have unique spectral responses
- Develop angular NB to BB model from coincident MODIS and CERES radiances
  - Model based on solar, view and azimuth angles; cloud amount, phase, and optical depth; and geo-type
  - Use theory normalized to observations to fill in unsampled angular bins
- Apply CERES shortwave bidirectional and longwave directional models
  - Requires consistent scene identification between MODIS and GEO

Spectral scene type reflectances



- Need to estimate entire spectra range (BB) from visible channel (NB)

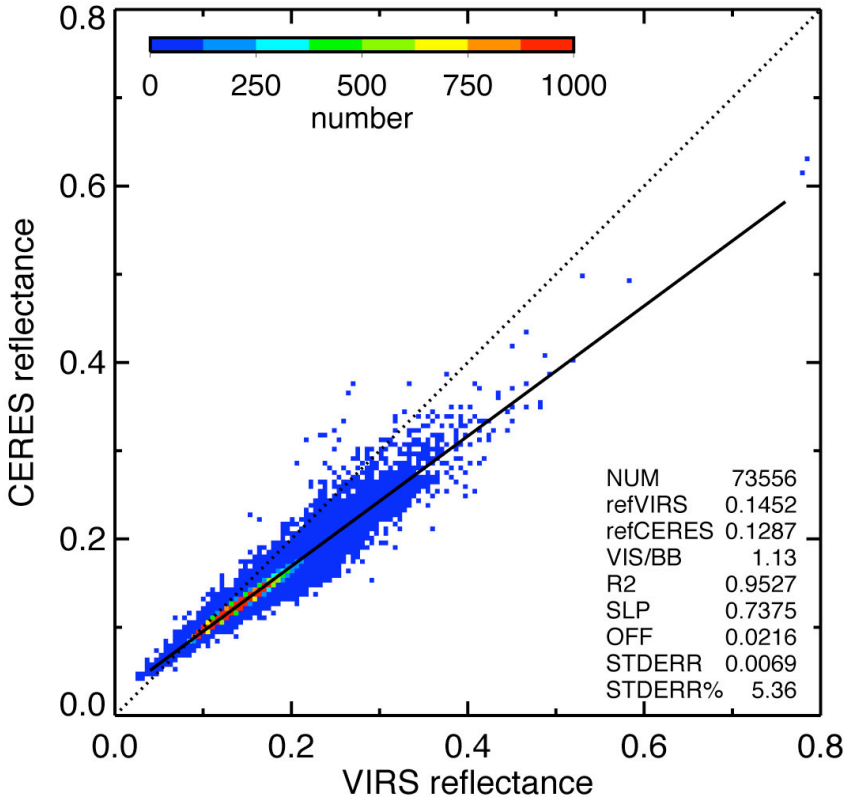
GEO visible spectral response functions



Angular VIRS and CERES Bin Reflectances

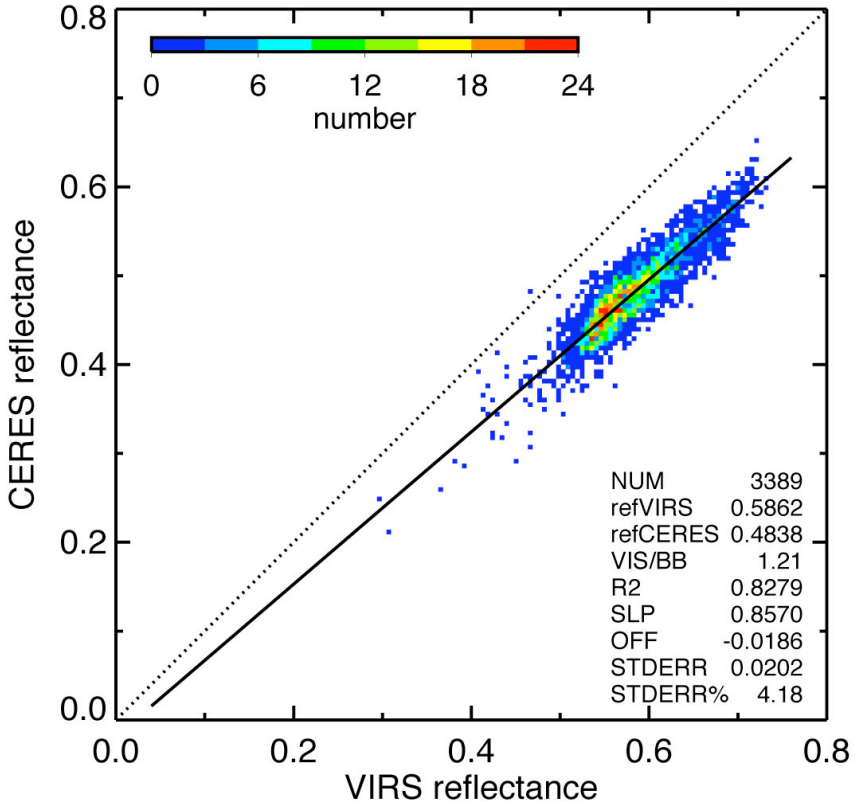
CLEAR OCEAN GLINT BIN

VZA=35° AZA=20° SZA=35°

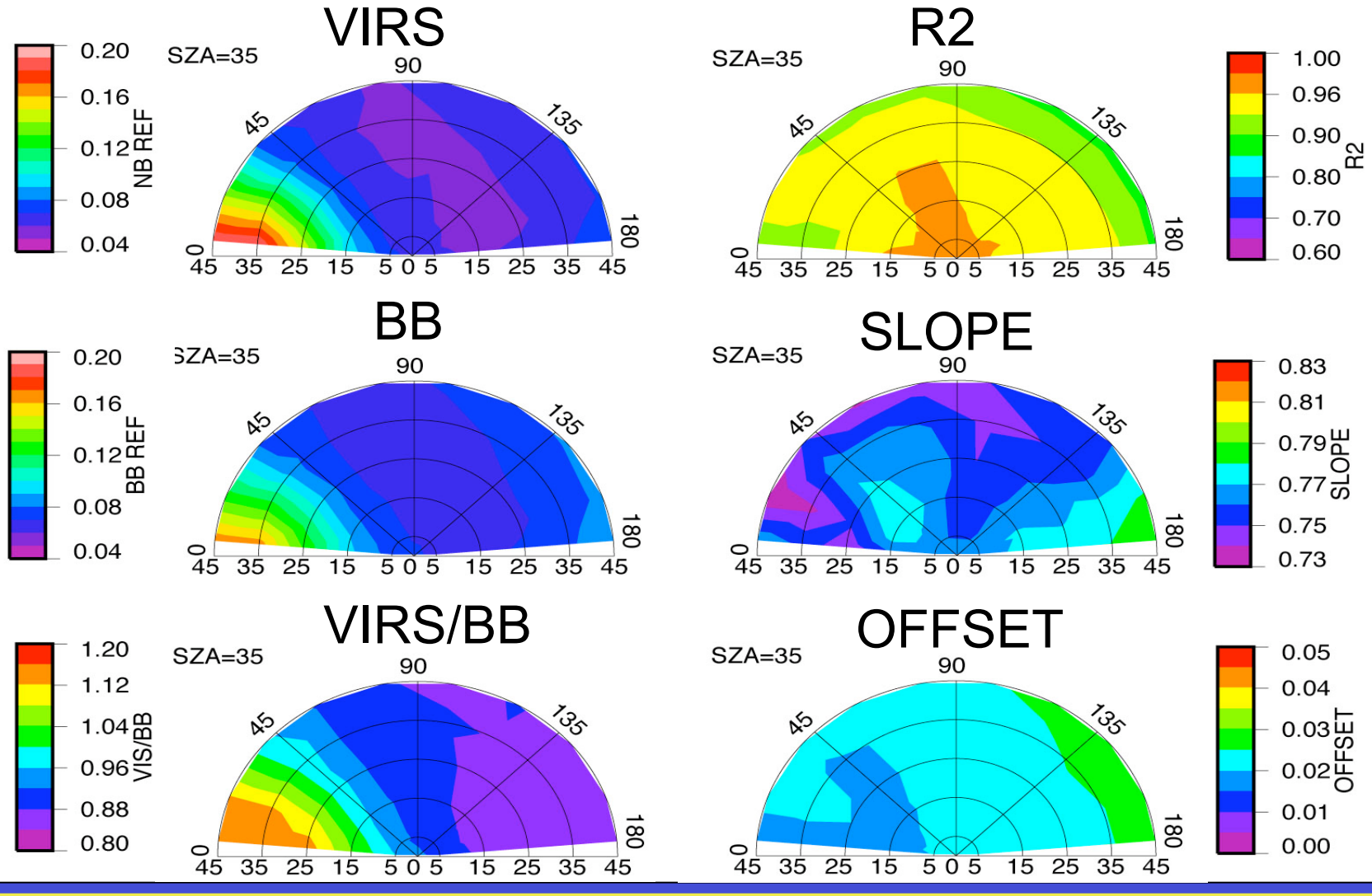


OVERCAST OCEAN BIN

VZA=25° AZA=60° SZA=45° 18<τ<40 liquid

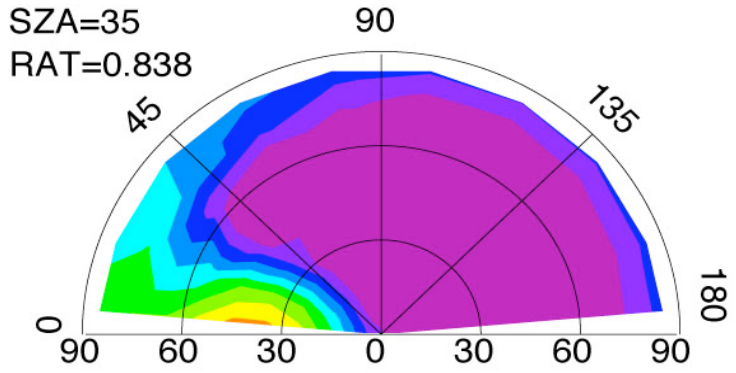


Clear OCEAN, SZA=35°

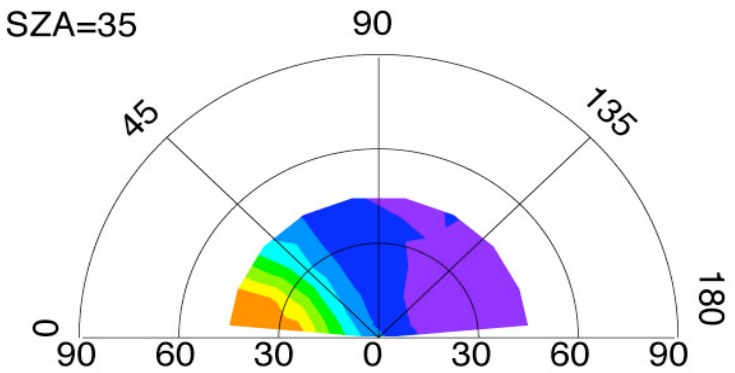


Theory Normalized to Observations

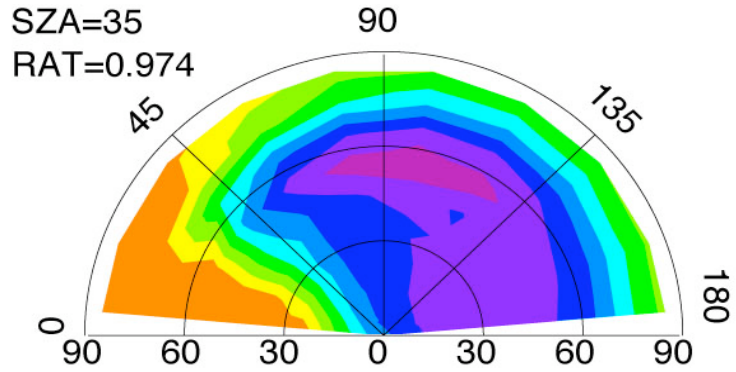
DISORT

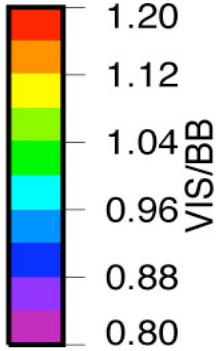


VIRS



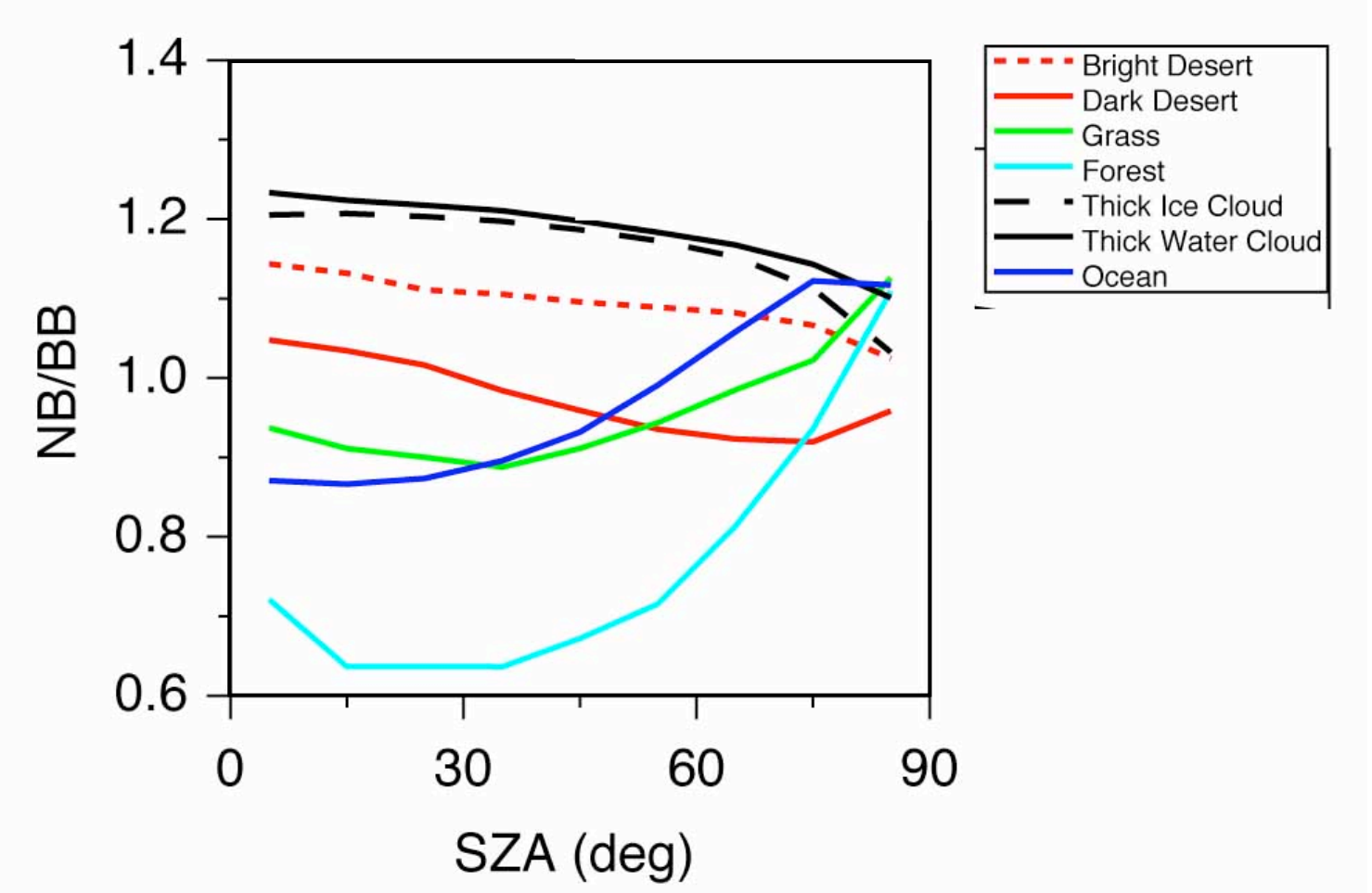
DISORT+VIRS





VIS/BB ratio
Ocean
sza=35°

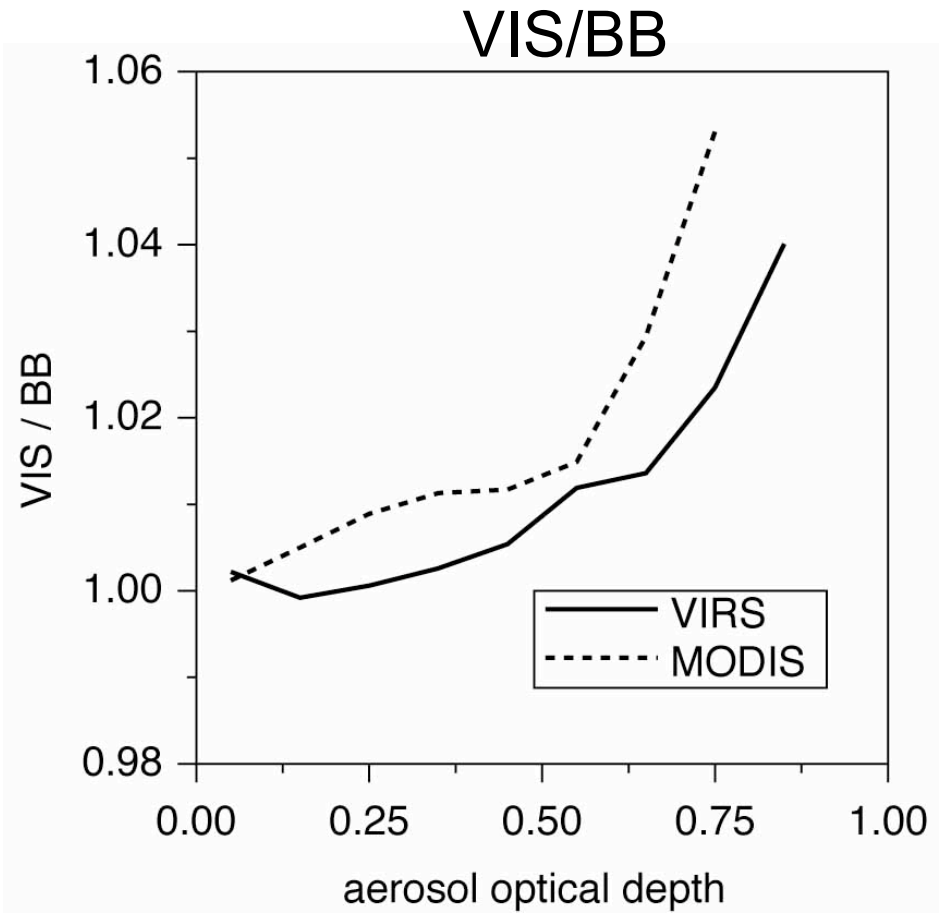
NB to BB directional models

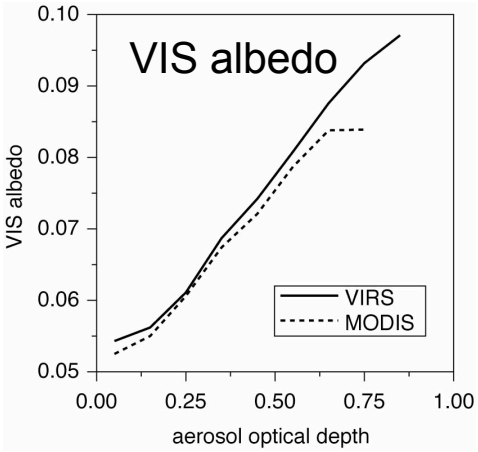


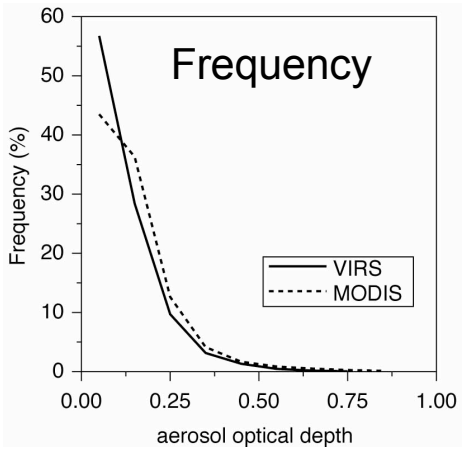
Possible NB to BB Angular Parameters

- Clear ocean aerosols
  - up to ~ 4% error (models w/o aerosols)
- Ozone ~ 4%
- Precipitable Water ~ 4-5%

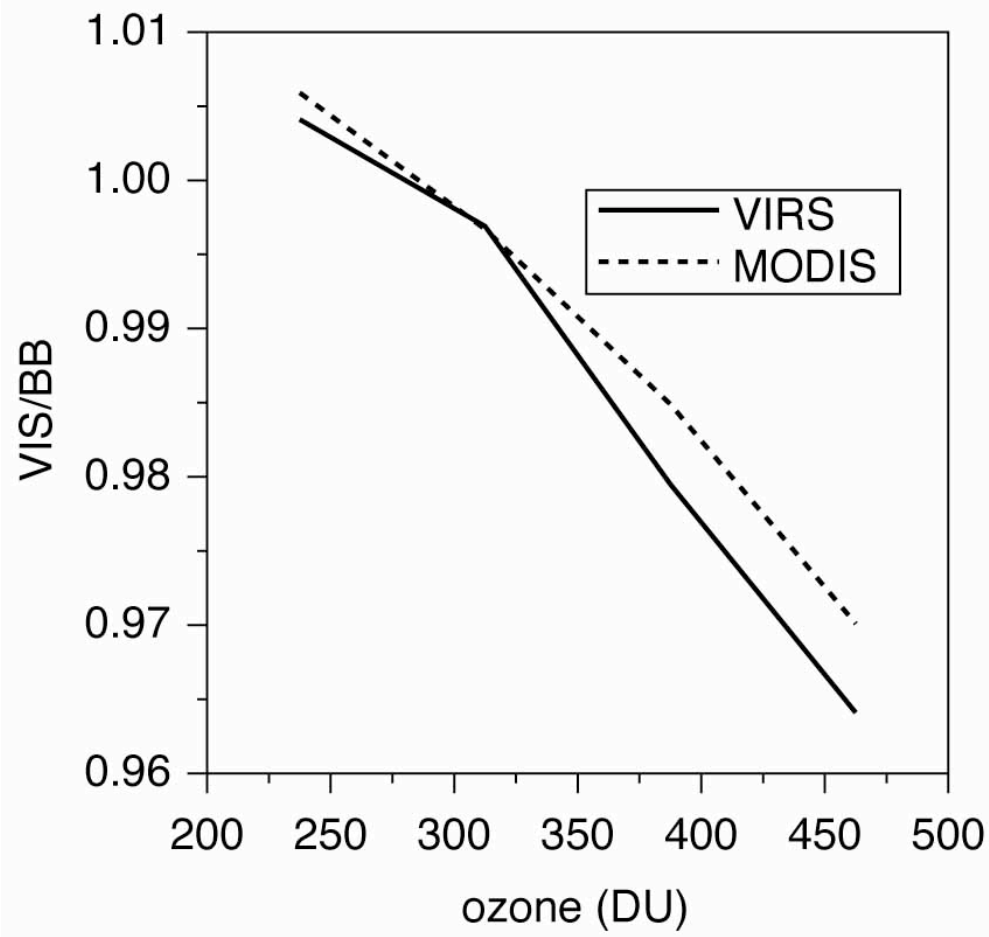
NB to BB vs Ocean Aerosol Optical Depth

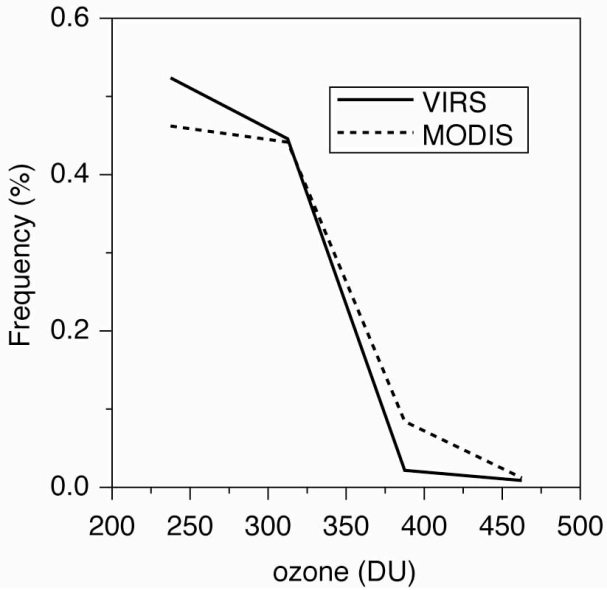




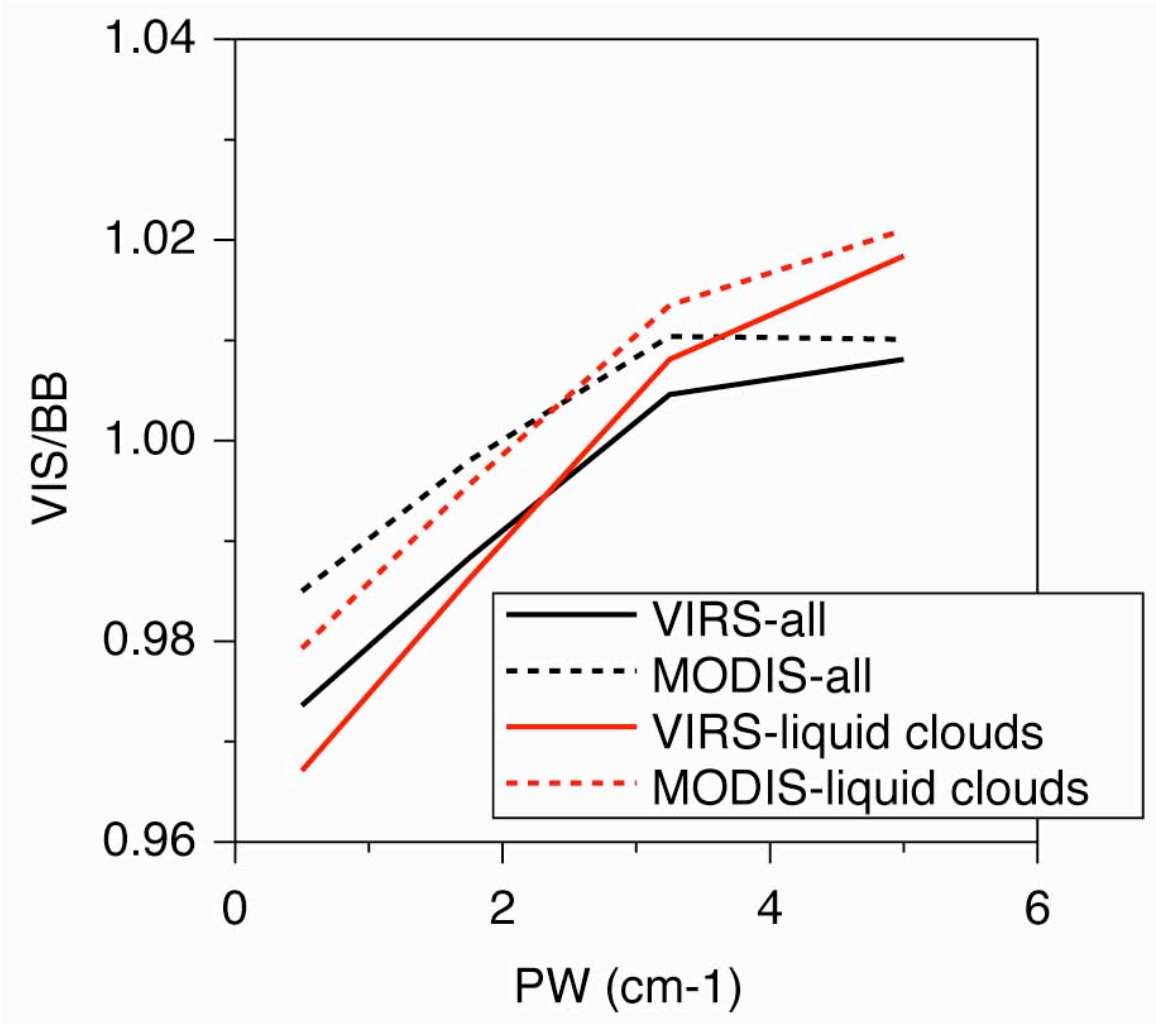


NB to BB vs Ozone





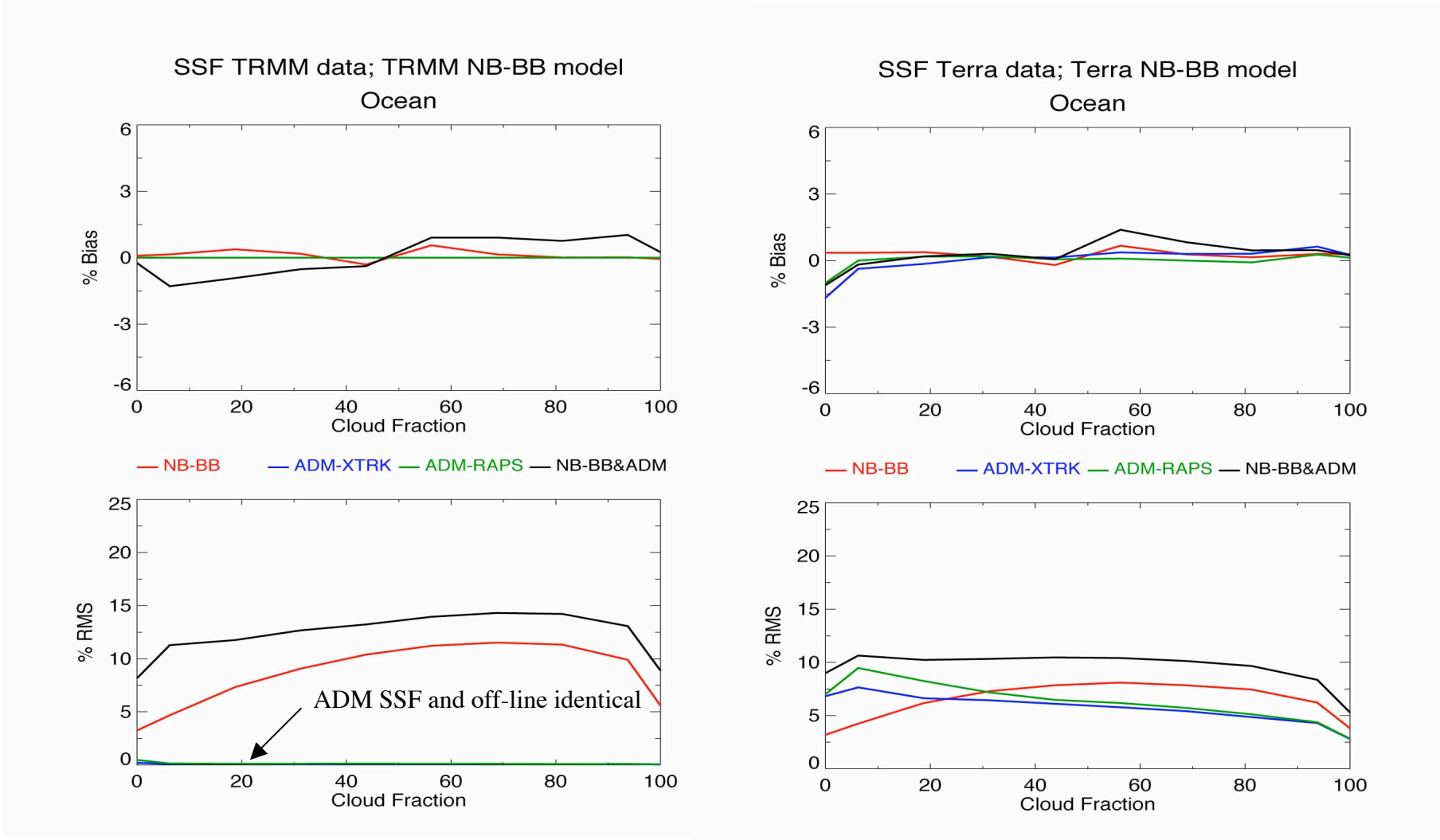
NB to BB vs PW


1.04
1.02
1.00
0.98
0.96
VIS/BB
0
2
4
6
PW (cm-1)
VIRS-all
MODIS-all
VIRS-liquid clouds
MODIS-liquid clouds

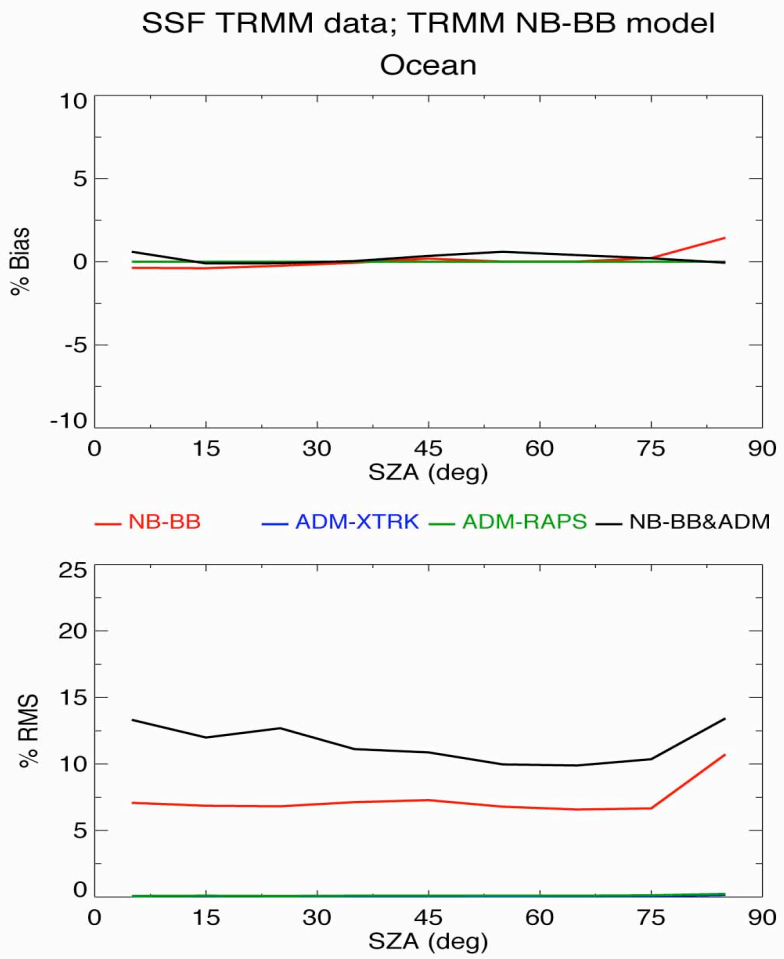
SSF imager NB-BB

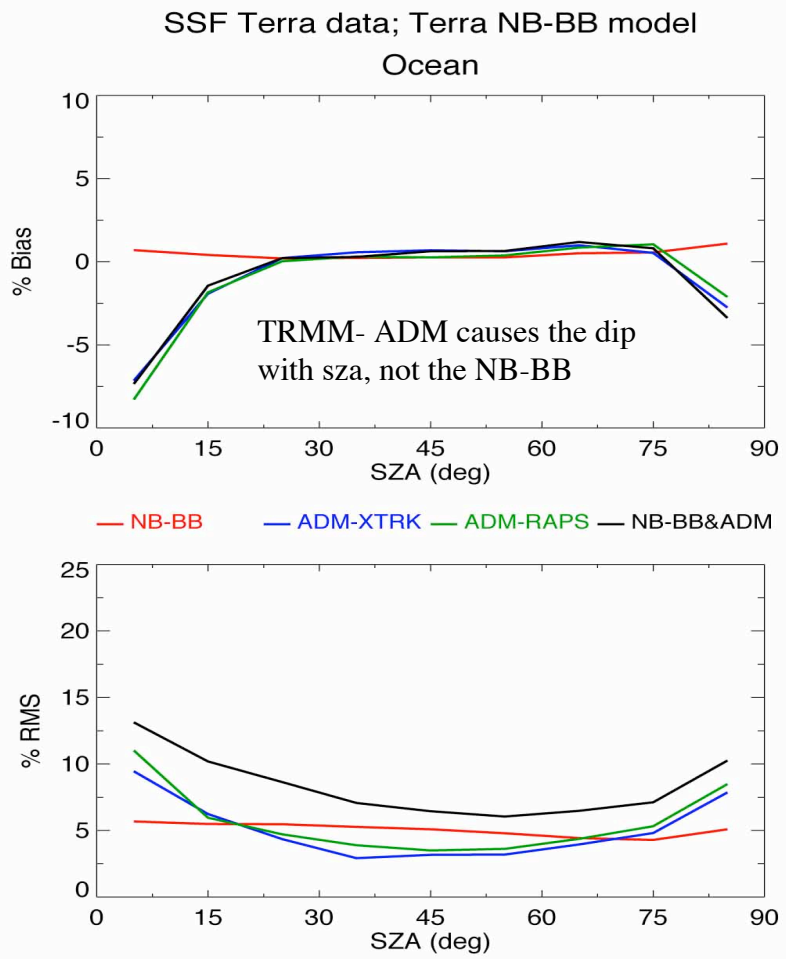
- Check TISA off-line TRMM ADM code
  - Compare SSF fluxes with ADM fluxes derived from radiances
  - Check for differences between Terra SSF fluxes and TRMM ADM derived fluxes
- Monitor the propagation of error
  - NB-BB, ADM, (RAPS) NB-BB & ADM
  - Check for differences between TRMM and Terra

NB to BB SSF errors -cloud amount



NB to BB SSF errors -sza

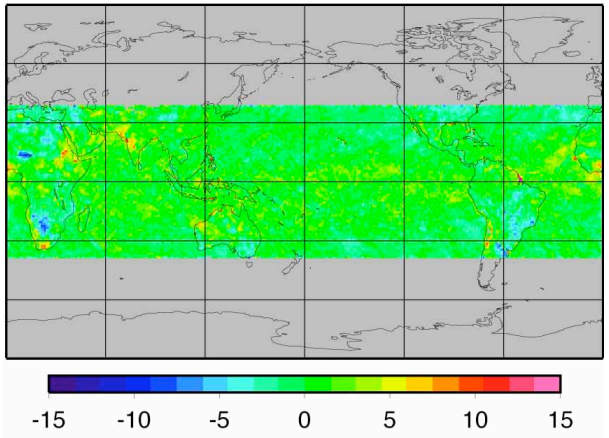




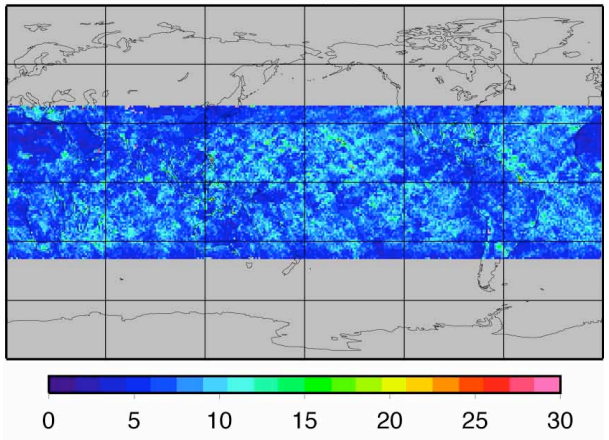
NB to BB SSF regional errors -TRMM

TRMM data, TRMM NB-BB

BIAS (%)

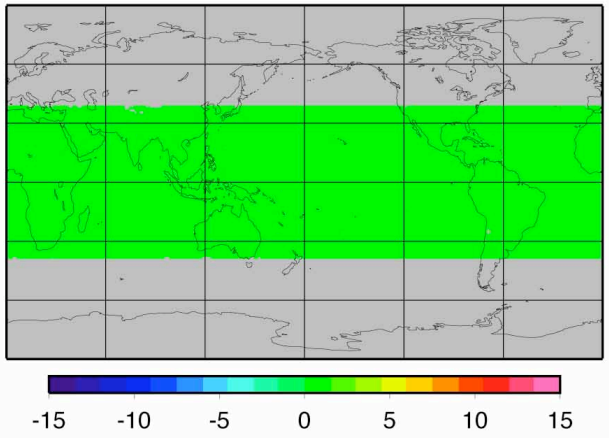


RMS (%)

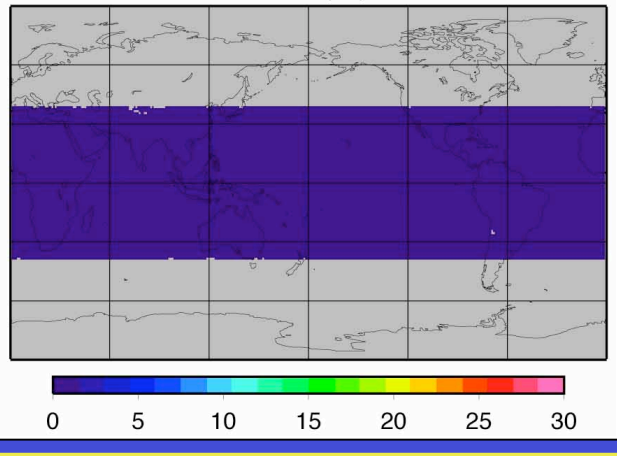


TRMM data, TRMM ADM

BIAS (%)

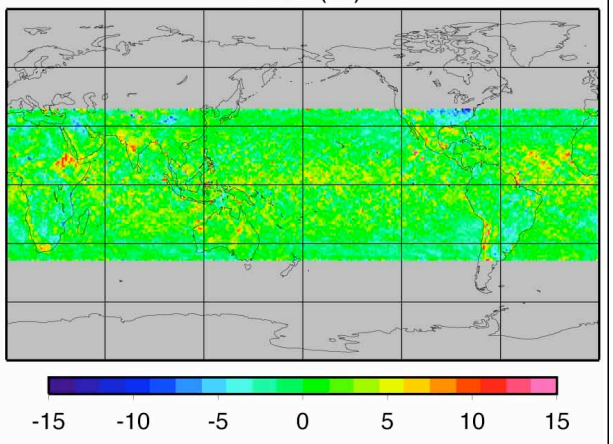


RMS (%)

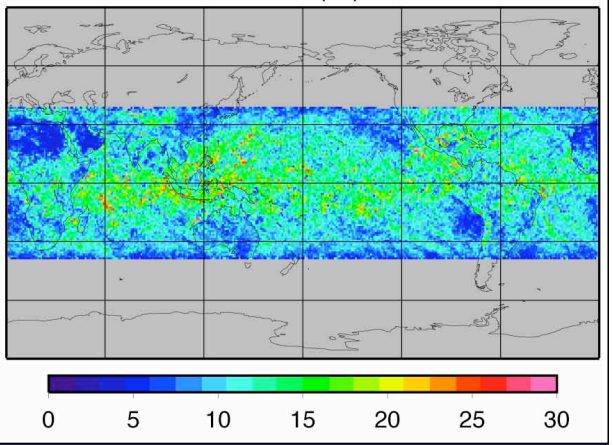


TRMM data, TRMM NB-BB & TRMM ADM

BIAS (%)



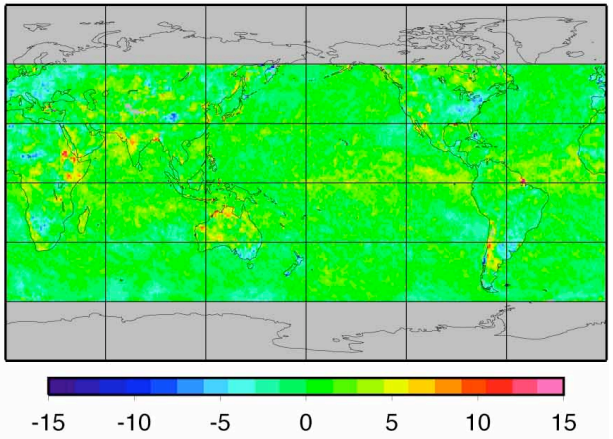
RMS (%)



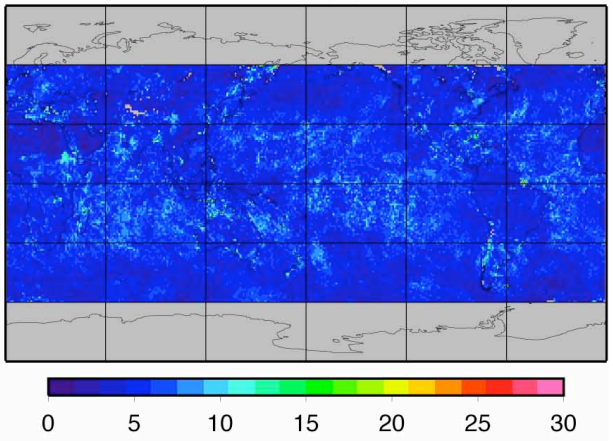
NB to BB SSF regional errors -Terra

Terra data, Terra NB-BB

BIAS (%)

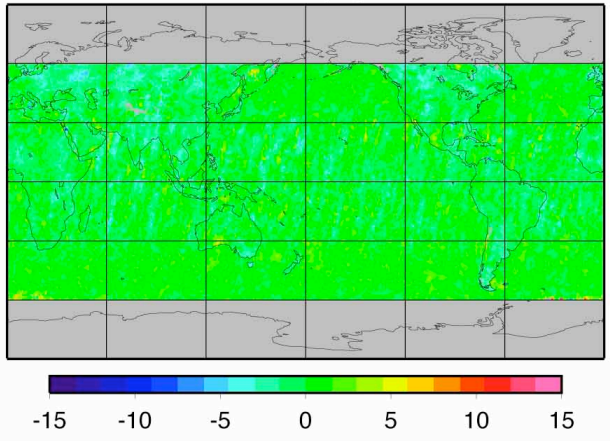


RMS (%)

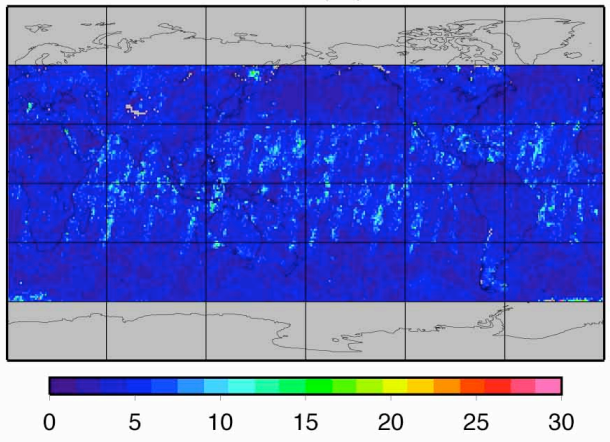


TERRA data, TRMM ADM

BIAS (%)

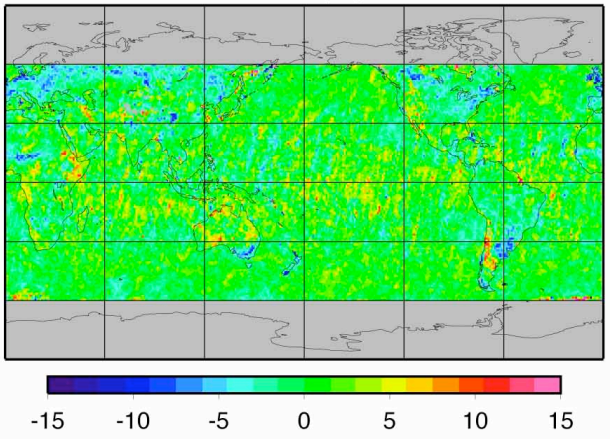


RMS (%)

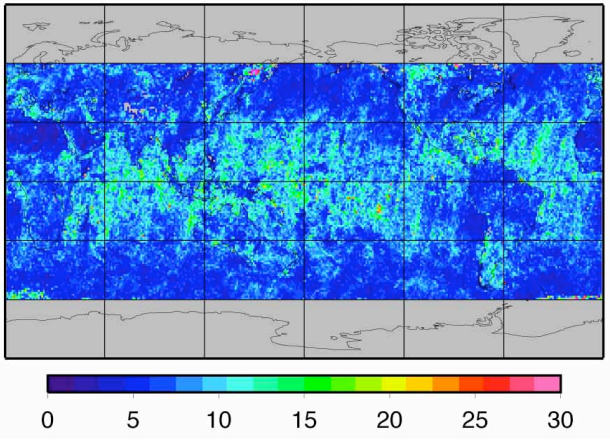


Terra data, Terra NB-BB & TRMM ADM

BIAS (%)



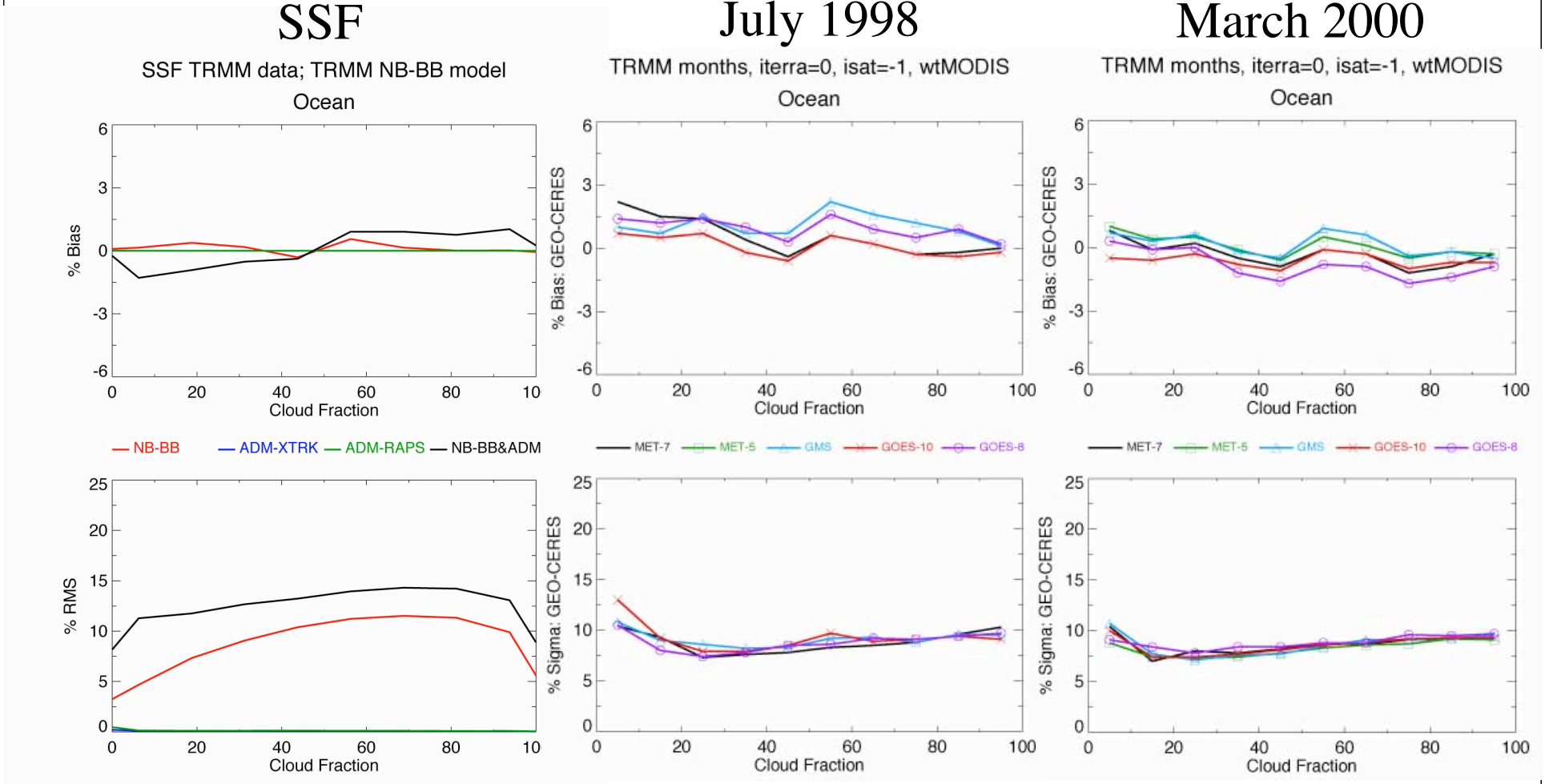
RMS (%)



GRIDDED imager NB-BB

- Compare gridded (1°) and SSF (20 km) results
  - Take gridded imager radiances -> NB-BB-> TRMM ADM -> move to local hourbox
  - Compare imager derived flux with the gridded CERES at local hourbox times
- Check for functionality
  - Longitude, no problems moving to local hour
  - Seasonal variability
  - Geostationary, as a basis to check for geo effects

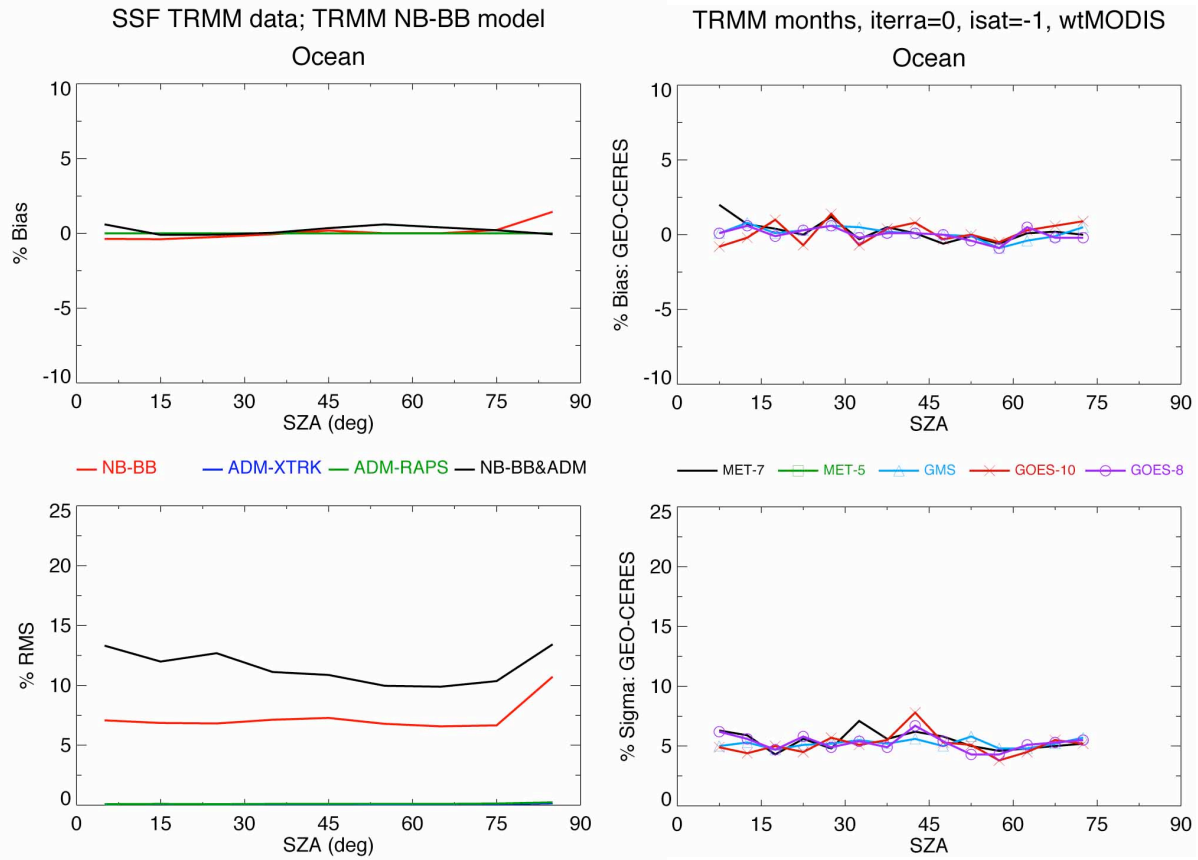
NB to BB TRMM gridding errors -cloudamt



NB to BB TRMM gridding errors -sza

SSF

July 1998

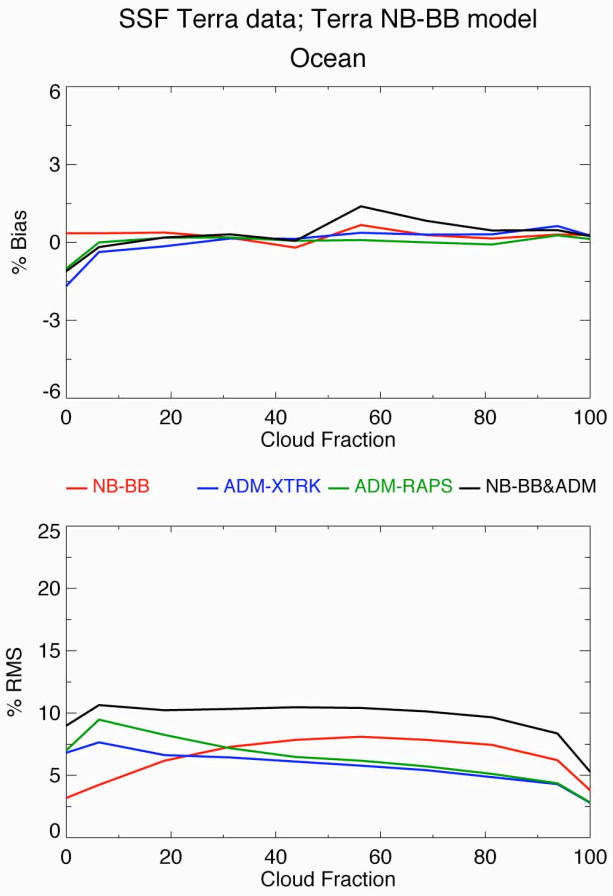


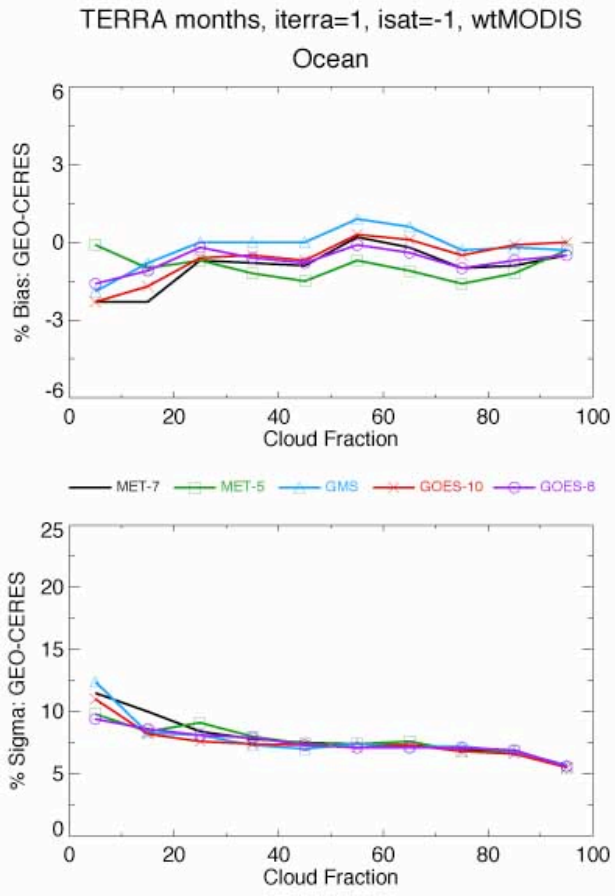
NB to BB TERRA gridding errors -cloudamt

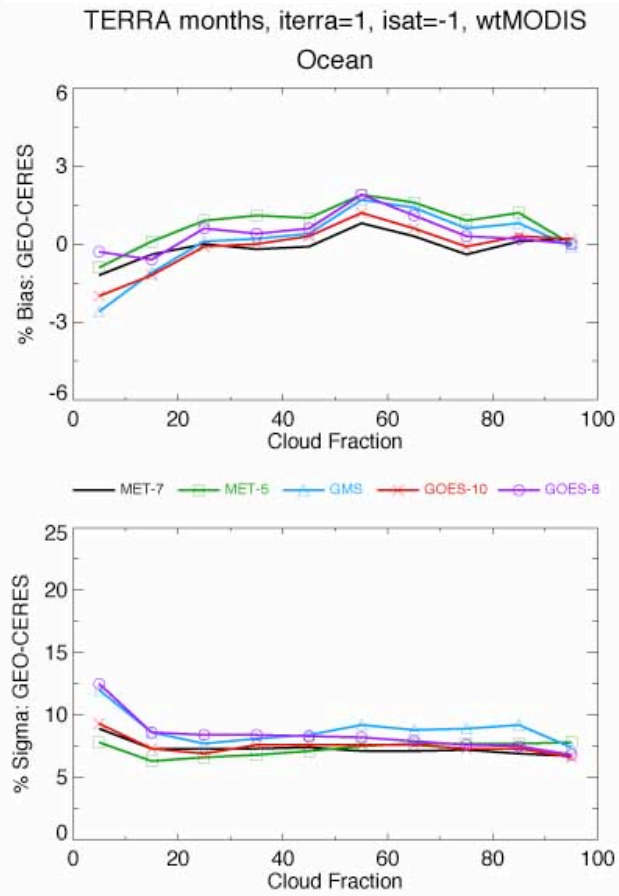
SSF

Jan 2001

July 2001





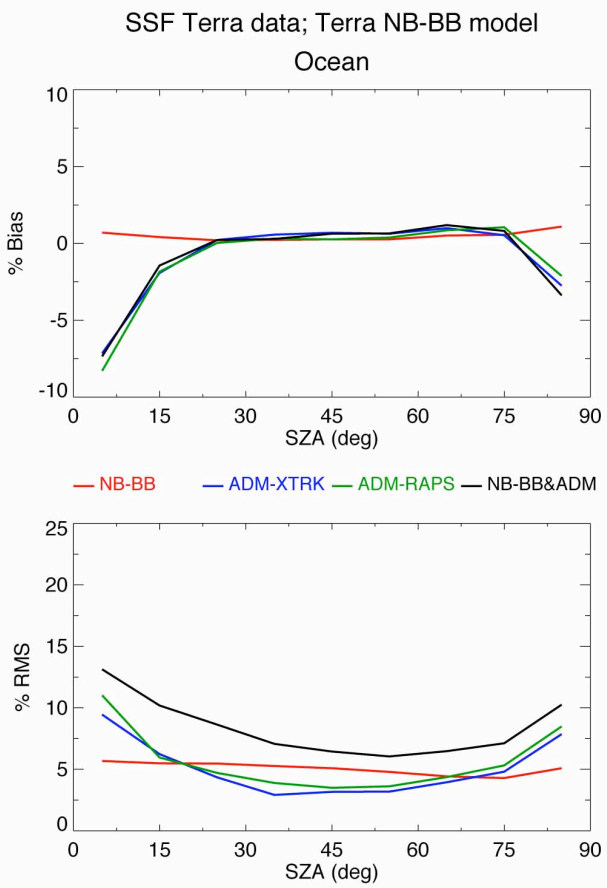


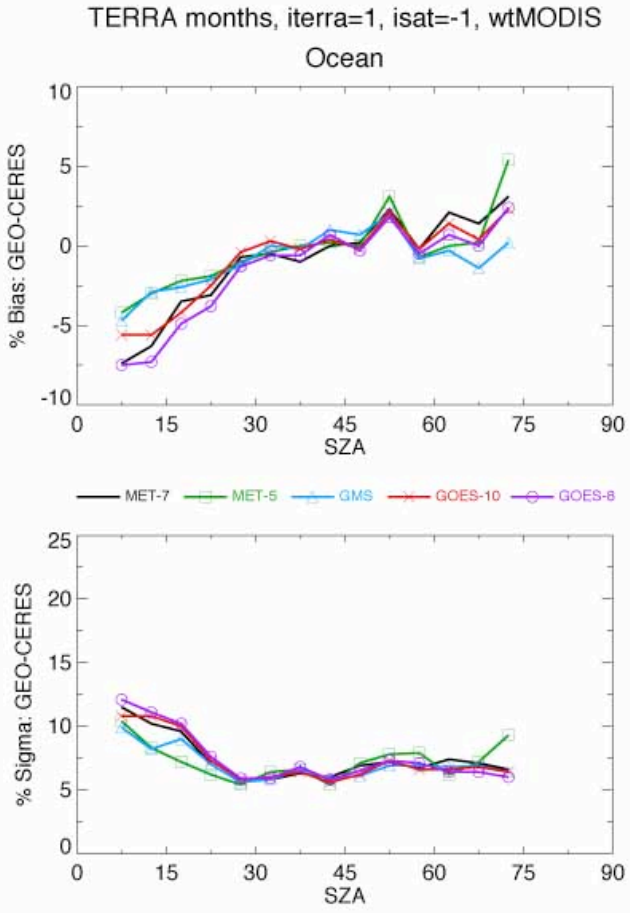
NB to BB TERRA gridding errors -sza

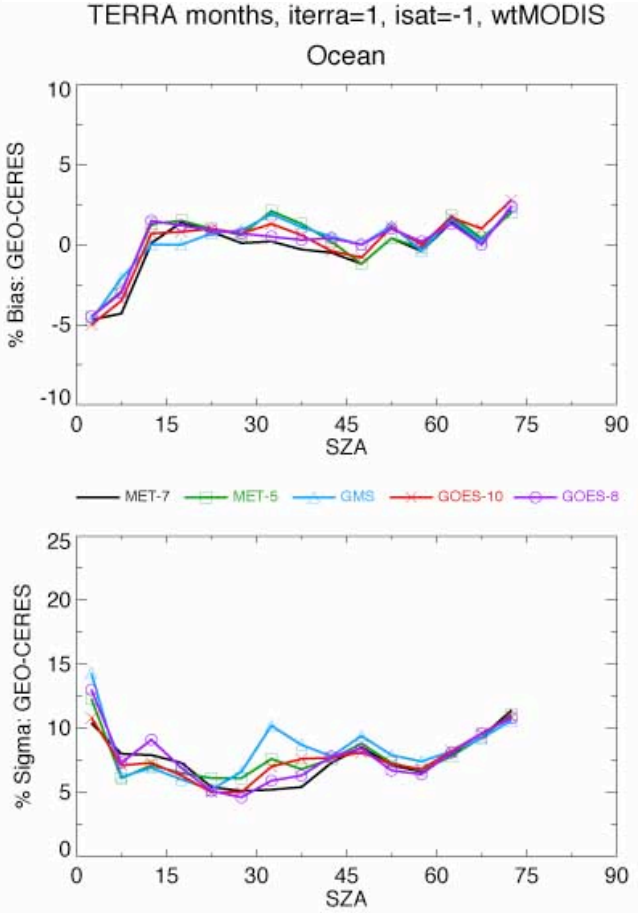
SSF

Jan 2001

July 2001





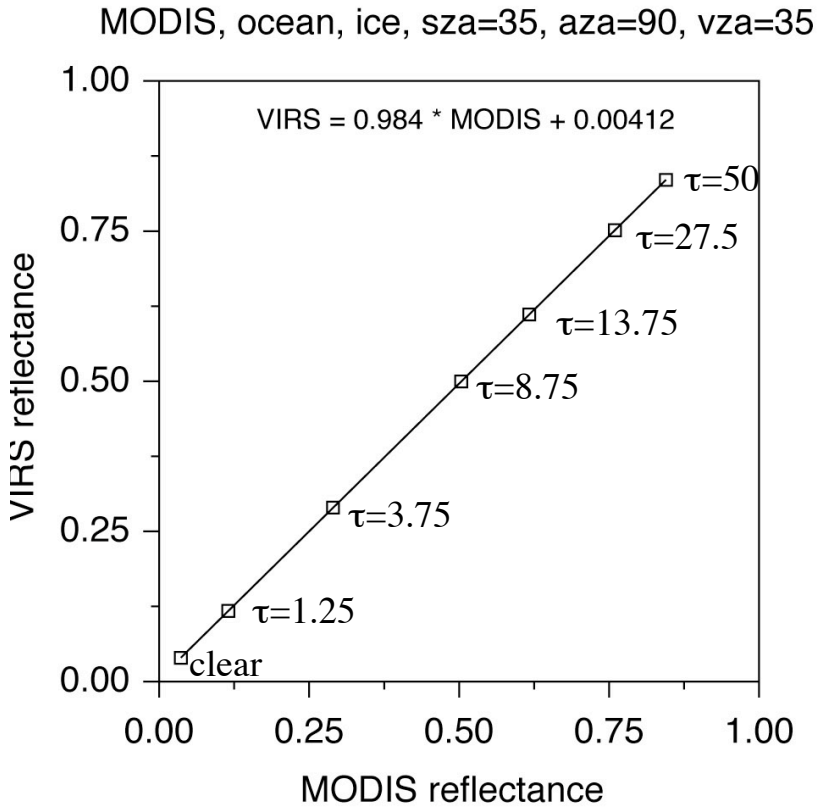


GGEO to NB adjustment

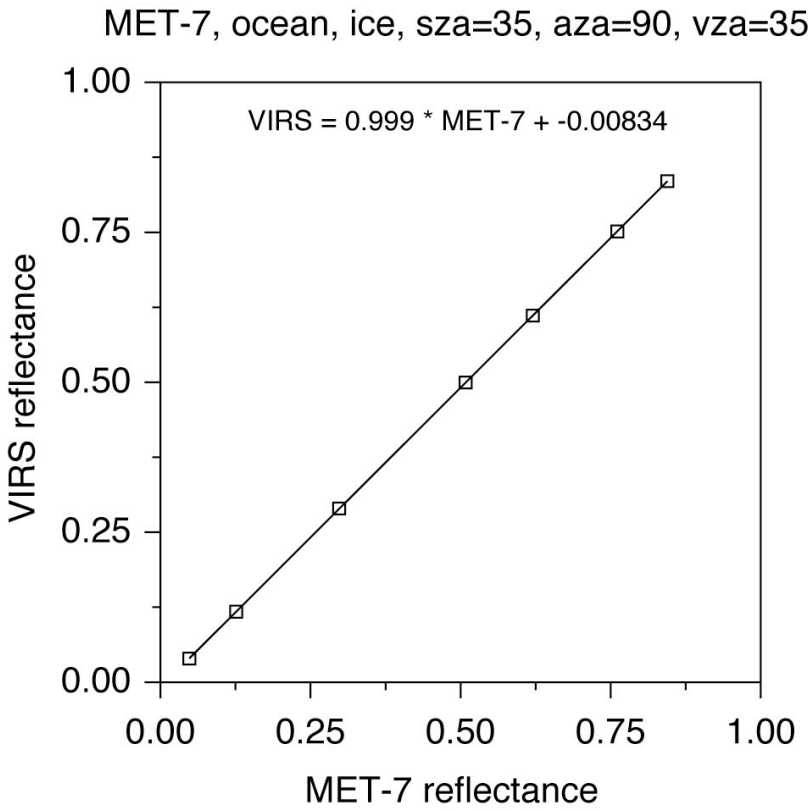
- GGEO radiances are first converted to MODIS or VIRS equivalent radiances using theory
  - Same angular bins as the MODIS or VIRS NB to BB except for optical depth.
  - Variation in optical depth for a given angular bin keeps the GGEO NB adjustment radiance based
- Theoretical GGEO NB adjustment based on
  - mid-latitude summer profile
  - DISORT scattering
  - Correlated-K (32 band) absorption of H_2O, CO_2, O_2, and O_3
    - Kato et al. 1999
  - Water clouds between 1-3 km
  - Ice clouds between 5-7 km
    - Yang et al. 2000 ice phase functions
    - Baum et al. 2000 ice particle distributions

GGEO to NB Adjustment

VIRS vs MODIS



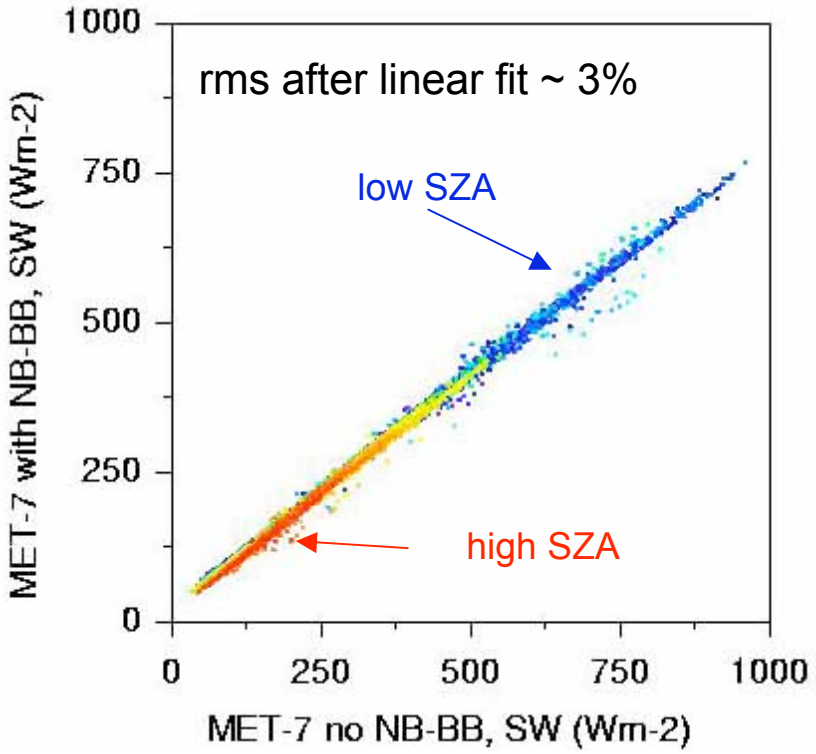
VIRS vs MET-7



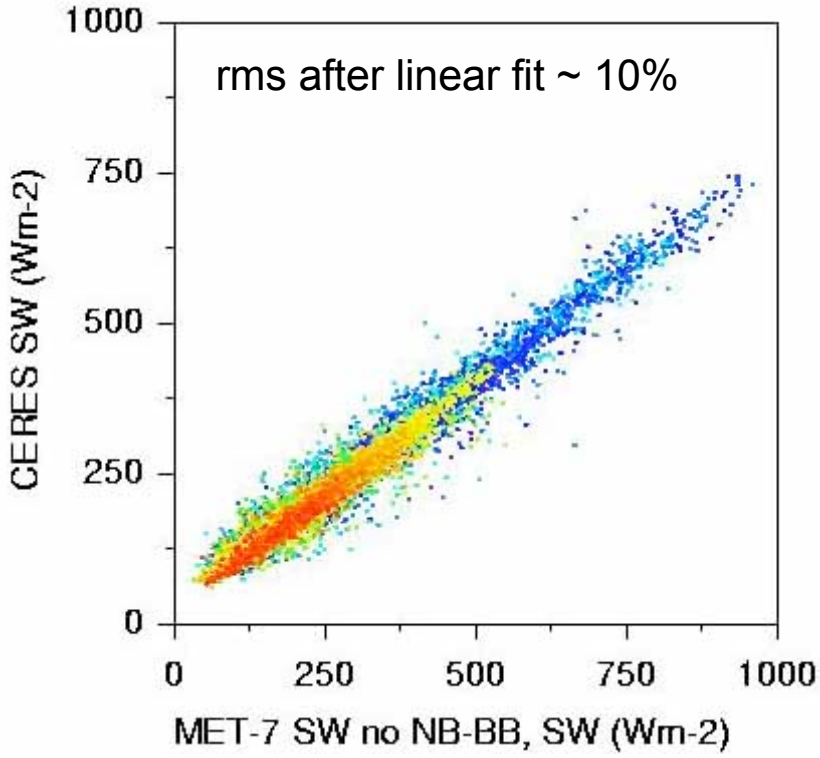
CERES and MET-7 linear regression

MET-7, OCEAN, July 2001, Δ15 minutes

Impact of NB-BB



RMS of MET-7 and CERES



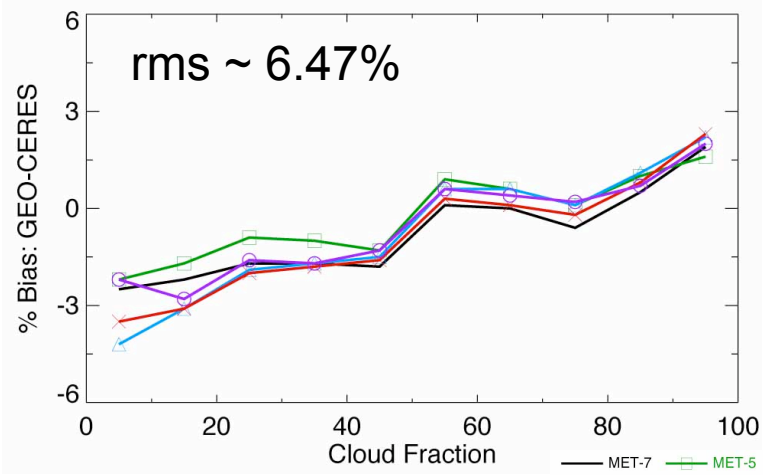
VIRS to MODIS adjustment, OCEAN, July 2001

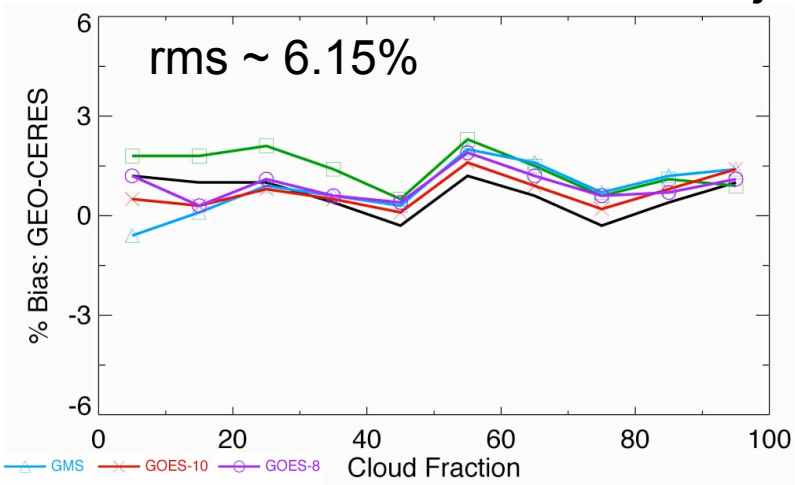
VIRS model

VIRS model with MODIS adj.

MODIS model rms ~ 6.05%

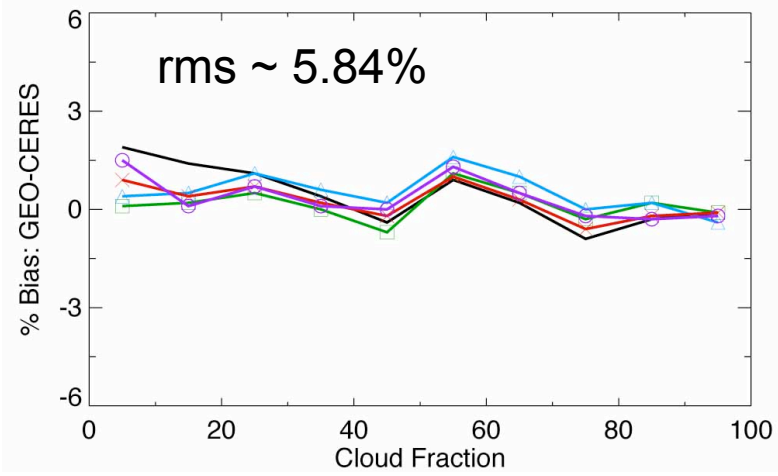
No linear fit

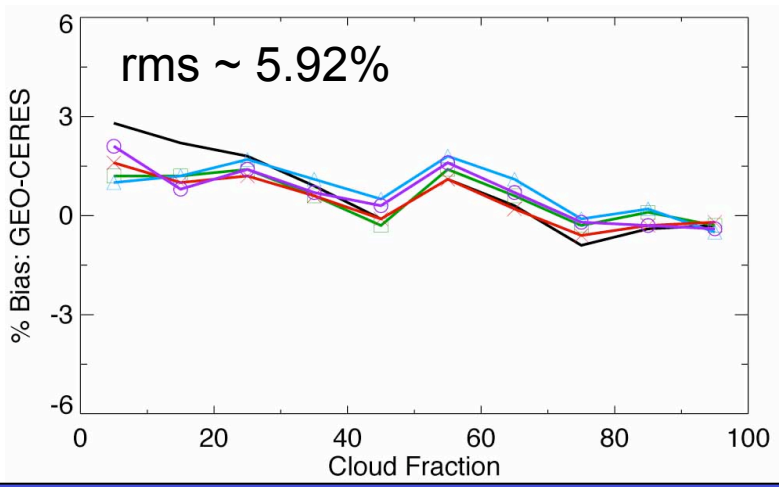




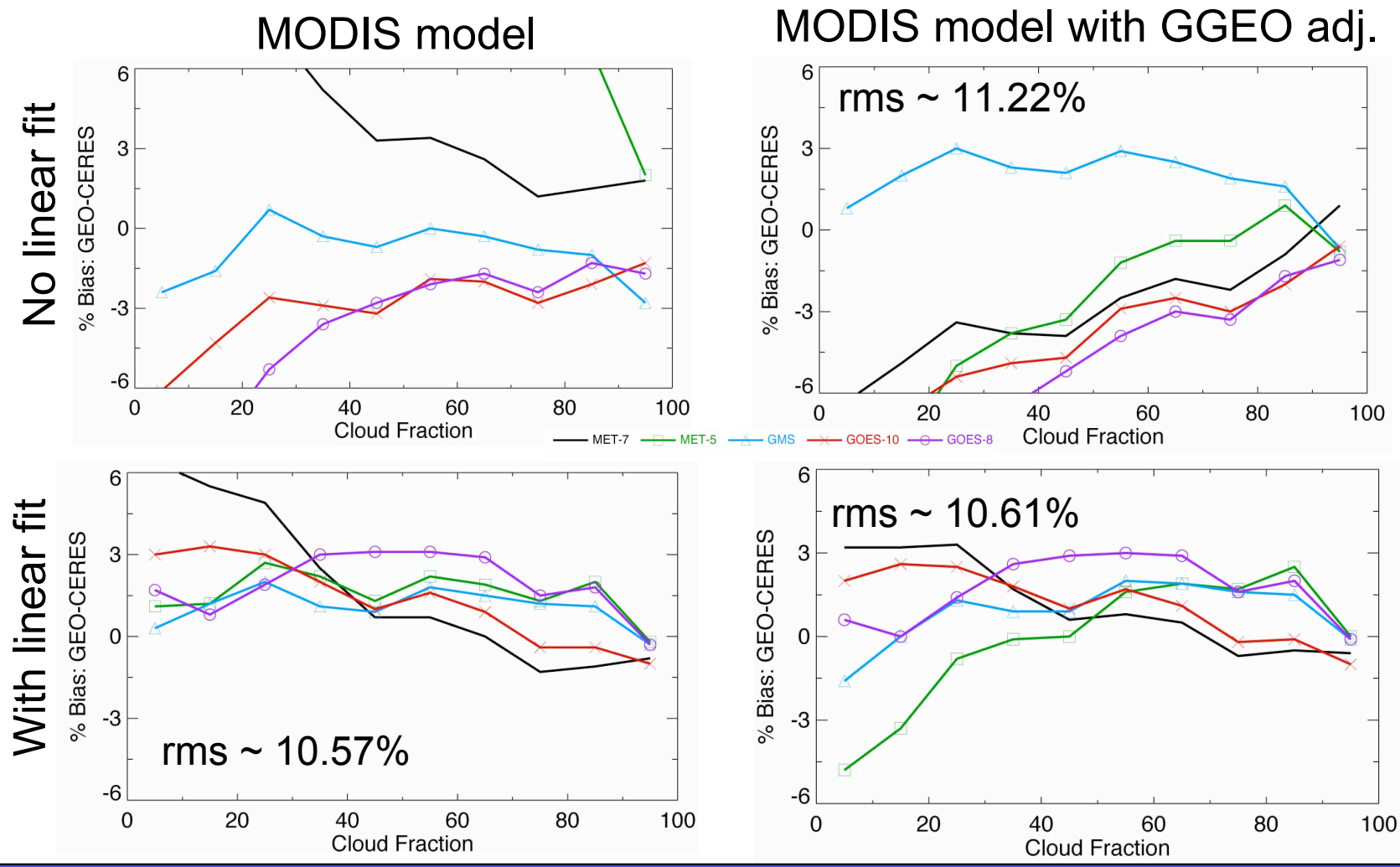
MODIS model rms ~ 6.02%

With linear fit





GGEO to NB adjustment



Error Analysis (%)

	VIRS	MODIS
XTRK NB-BB SSF (1 month)		3.1
XTRK NB-BB SSF (no ADM)	7.5	5.3
RAP NB-BB SSF	11.4	7.5
XTRK NB-BB gridded	5.3	6.1

	GGEO min	max
GGEO gridded (05 min)	9.4	12.4
GGEO gridded (15 min)	9.8	13.1
GGEO gridded (30 min)	10.9	13.8
GGEO gridded (60 min)	12.3	15.5

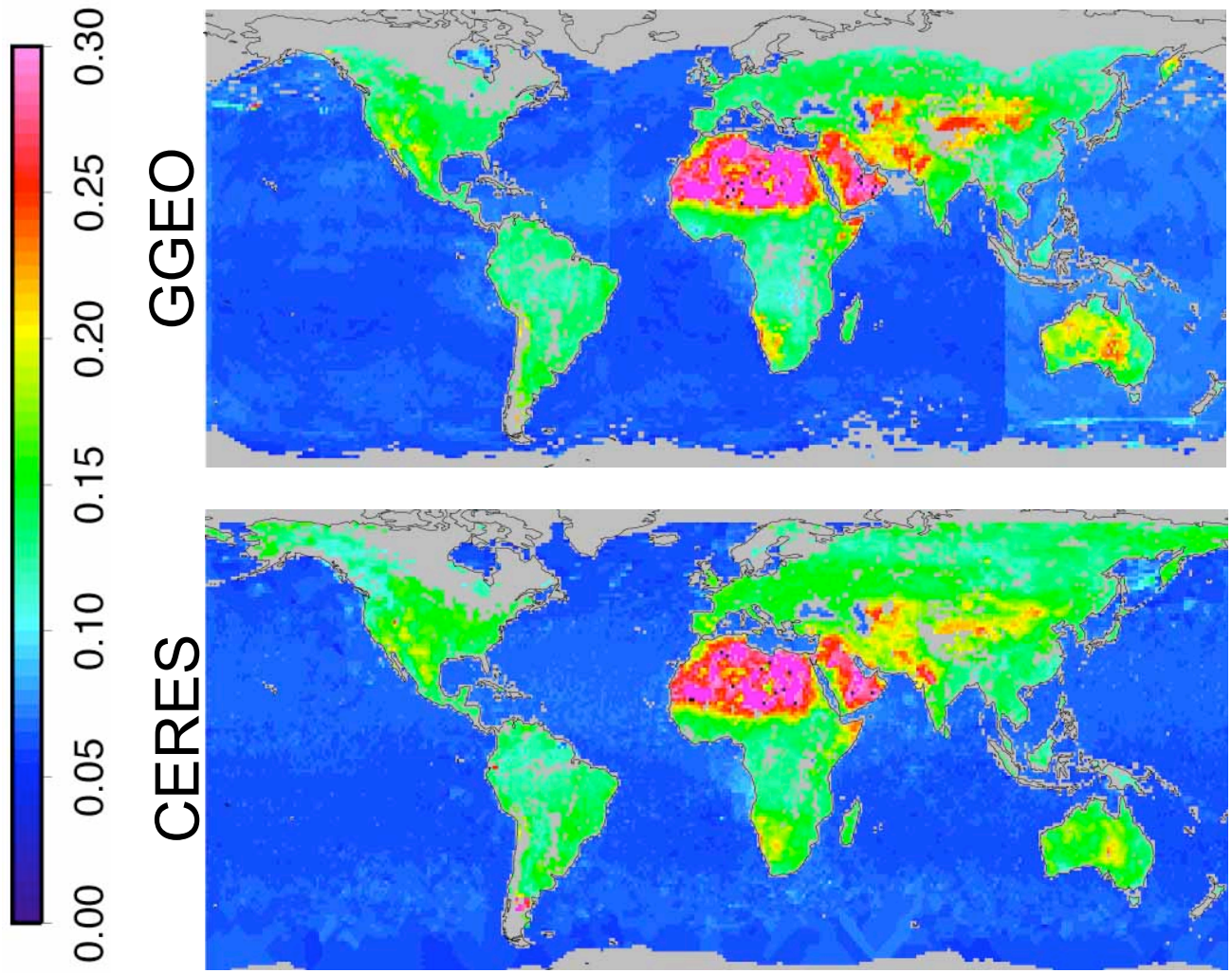
GEO SW Normalization

- GGEO SW flux not anchored on the CERES flux on coincident hourboxes as with LW
  - The instantaneous SW rms error is ~10-15%
  - Previous study indicated reduced rms errors only for the two surrounding hourboxes (Young et al. 1998)
- GGEO SW flux is normalized by the difference in the predicted GGEO and CERES clear-sky and overcast fluxes weighted by cloud fraction
  - Applied at the hourbox level
  - Predicted fluxes based at the monthly level
  - Each GEO satellite normalization done independently
    - To remove artifacts of calibration, especially the offset (clear-sky)
  - Fill hourboxes with GEO derived fluxes -> then insert CERES hourbox measurements -> temporally interpolate with CERES directional model

GEO SW Normalization - continued

- Predicted CERES clear-sky: Monthly regional clear-sky albedo from Terra/Aqua and CERES-TRMM directional model
- Predicted GGEO clear-sky albedo: Monthly regional clear-sky albedo from ~ 3 measurements/day and GGEO directional models
- Predicted CERES overcast: GGEO hourbox albedo is the sum of the predicted overcast and clear-sky albedo weighted by hourbox cloud fraction
  - GGEOalb = fclr*CERESalb_clr + Fcld*CERESalb_ovc
- Predicted GGEO overcast: Based on the linear regression of coincident GGEO and CERES hourbox fluxes for a month
- Apply normalization
  - Δalb = fclr*Δalbclr + fcld*Δalbcld

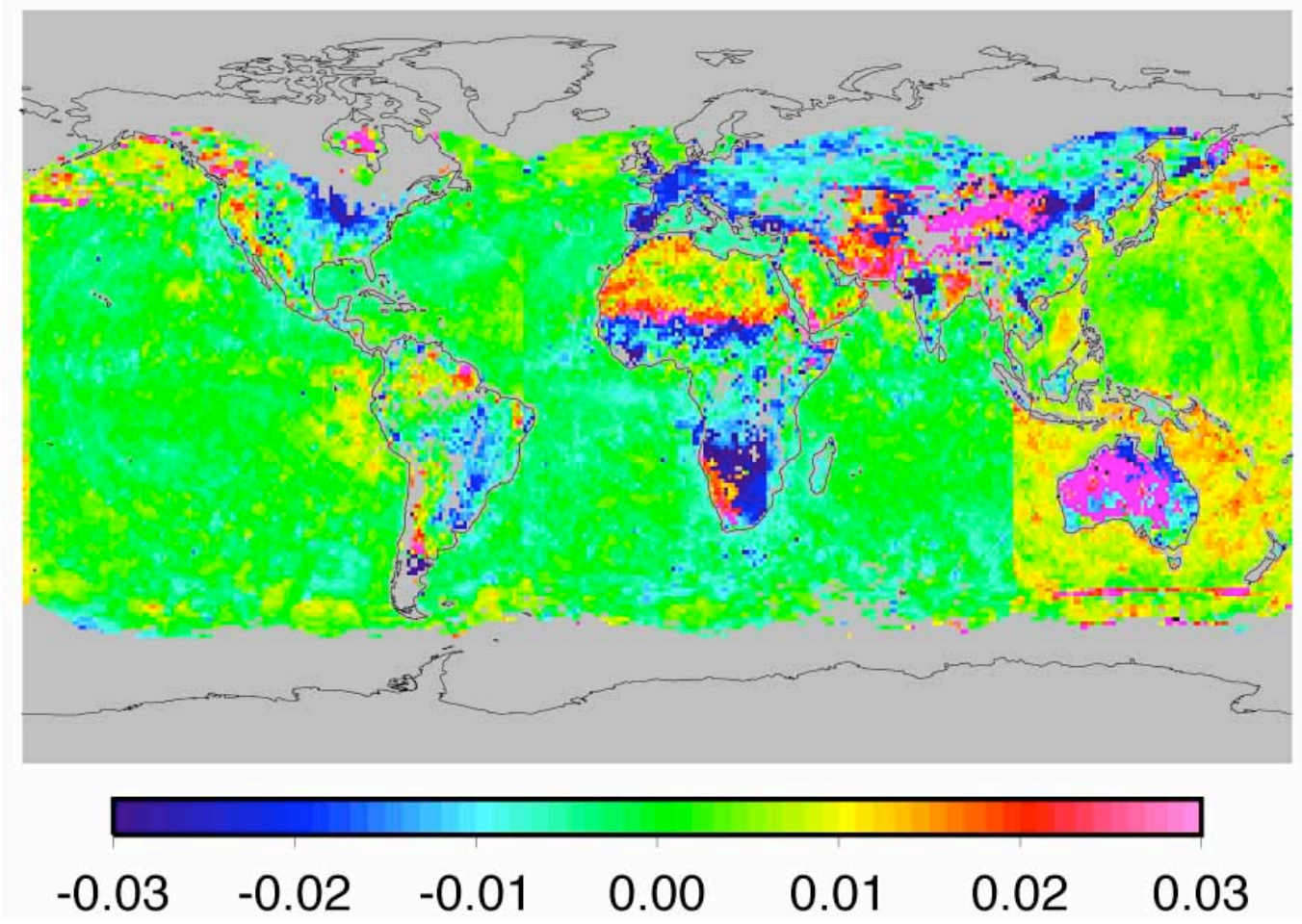
GEO & CERES clear-sky albedos



Overhead
Clear-sky
albedos
July 2001

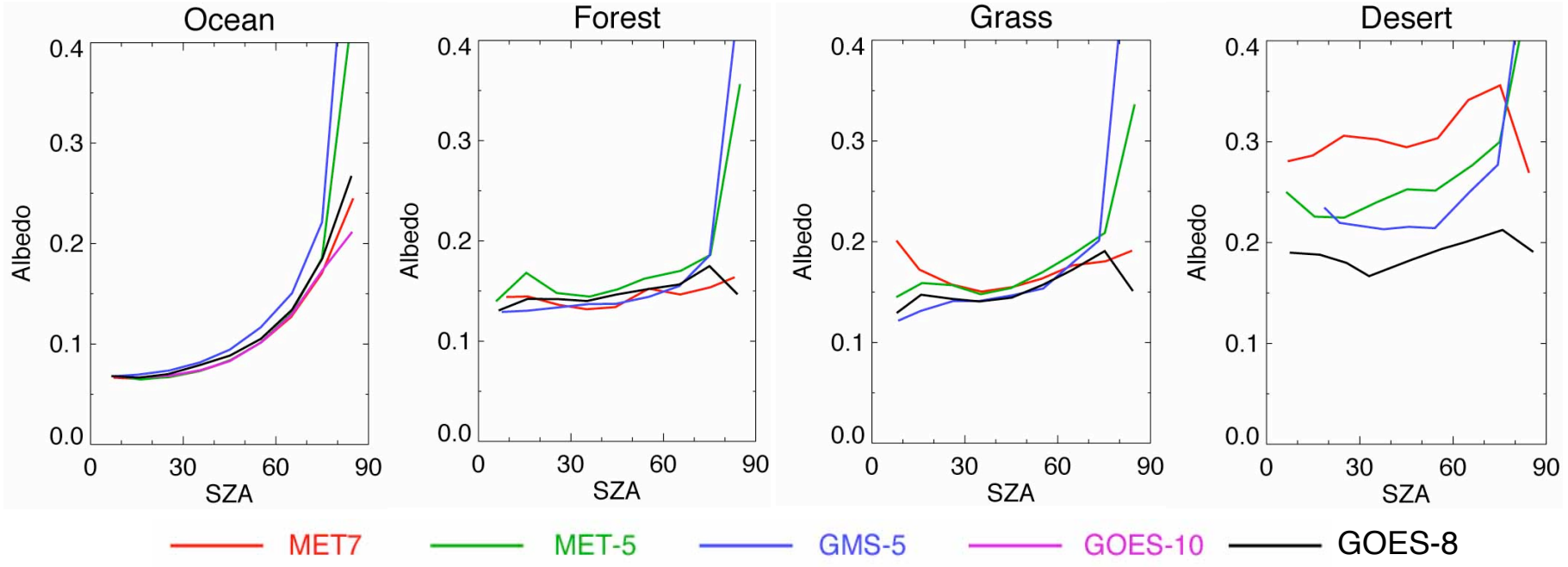
GEO - CERES clear-sky albedos

Overhead Clear-sky albedo difference, July 2001

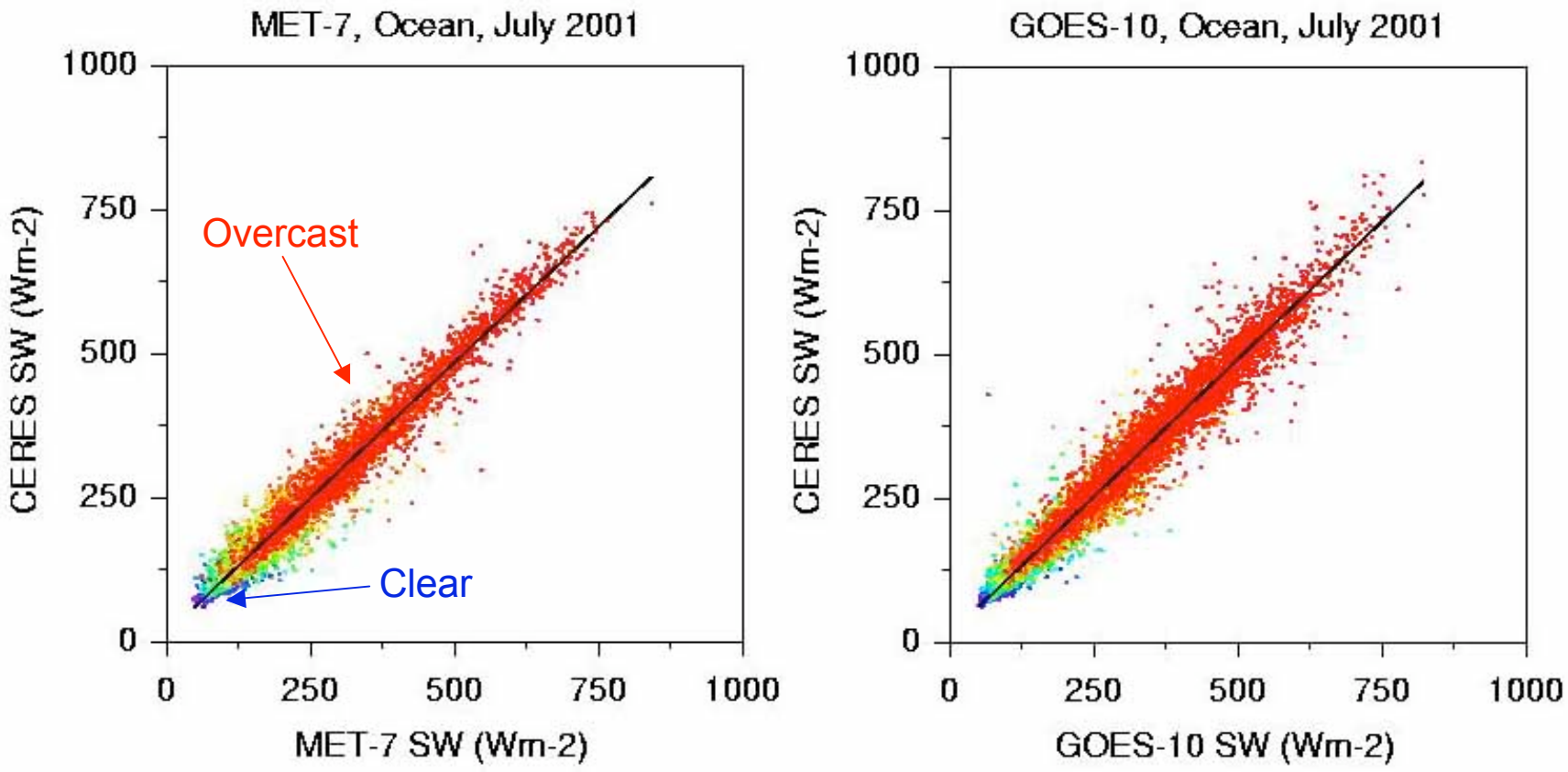


GEO clear-sky directional models

July 2001



CERES vs GEO overcast relationship



RMS~10%, Δ15 minutes

Validation

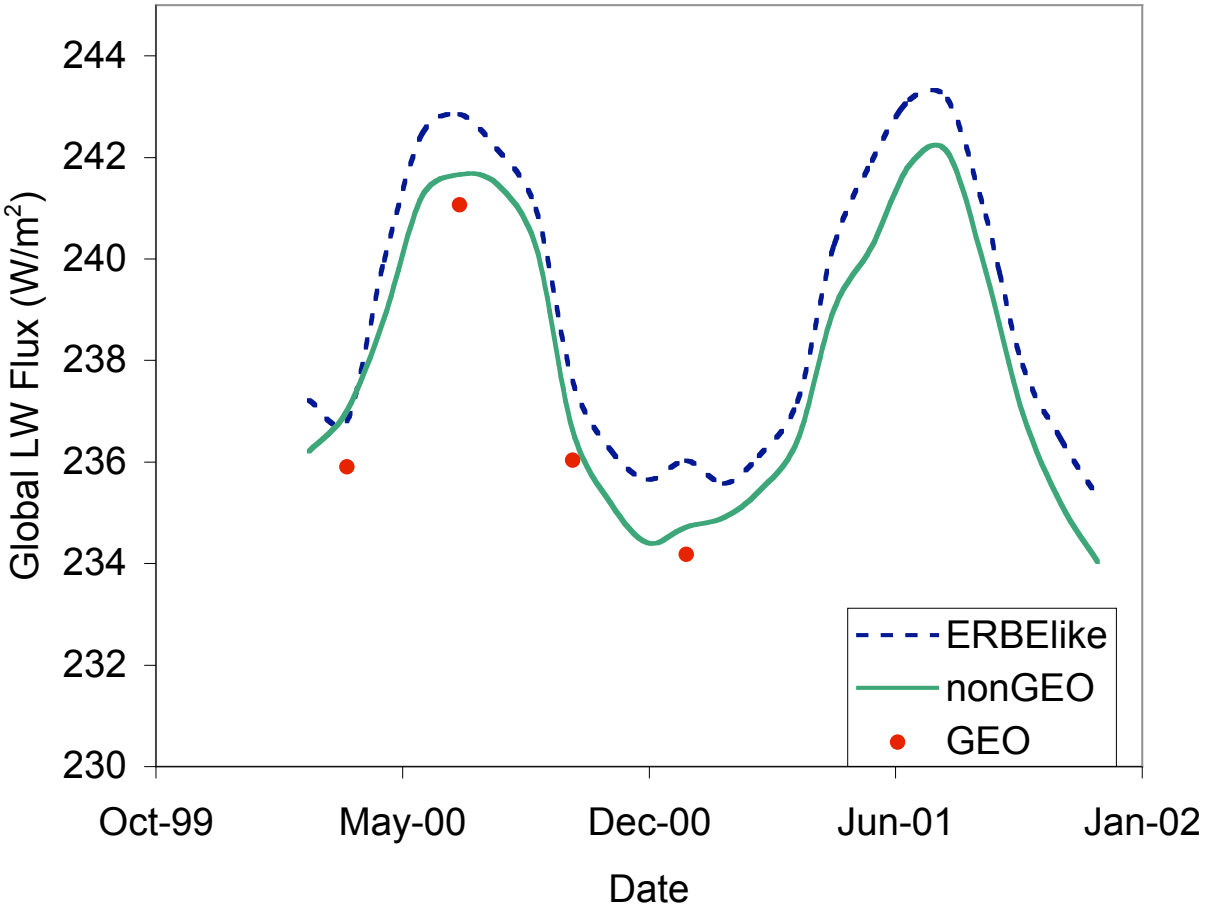
Comparison of Global Mean TOA Fluxes

- CERES produces 4 estimates of global flux
  - ERBElike
  - nonGEO SRBAVG
  - GEO SRBAVG
  - AVG (averaged from SYN product) (not shown)

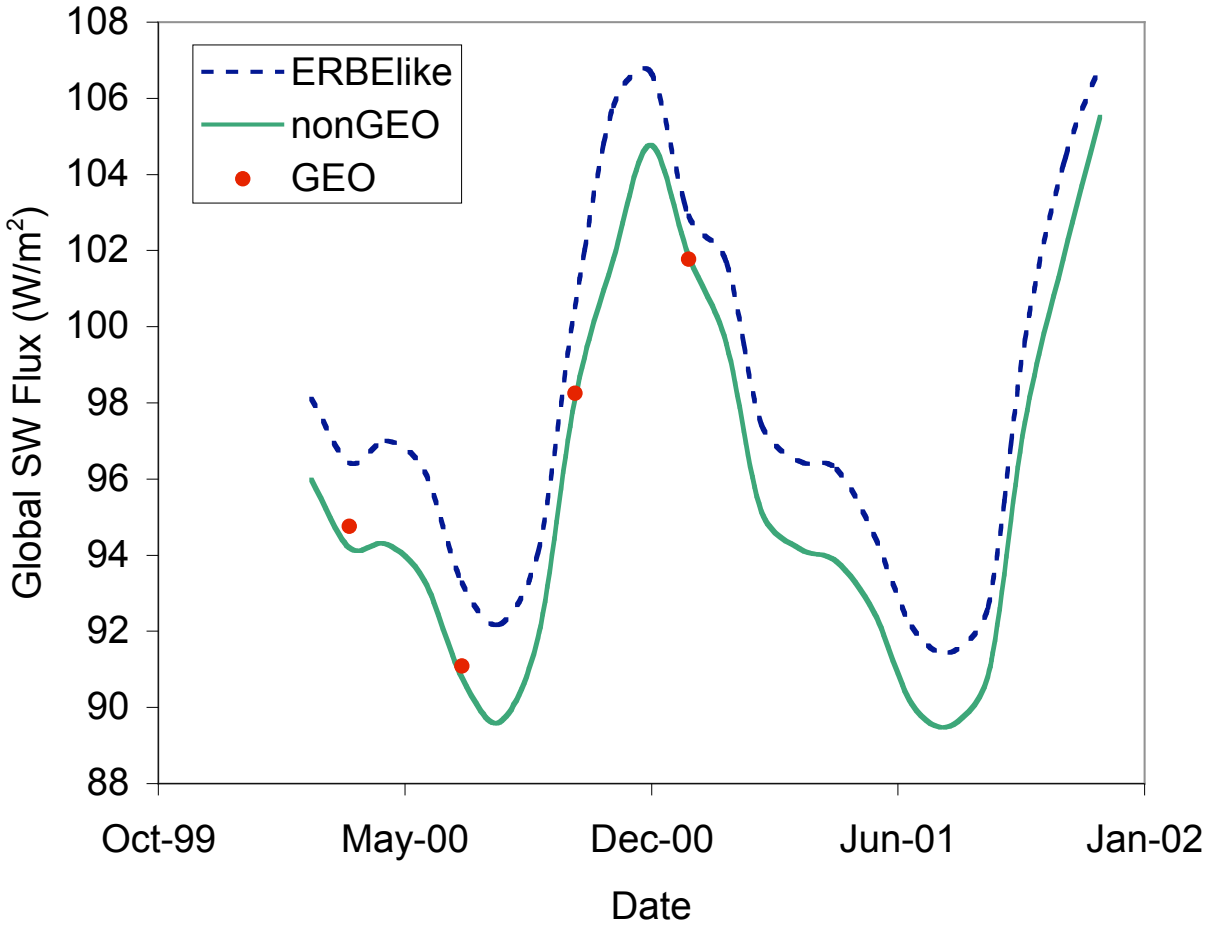
- ERBElike fluxes show global annual mean net flux imbalance of 4.5-5.5 W/m^2

- Compare ERBElike with SRBAVG means to see if improvements in ADM and TISA change the global net

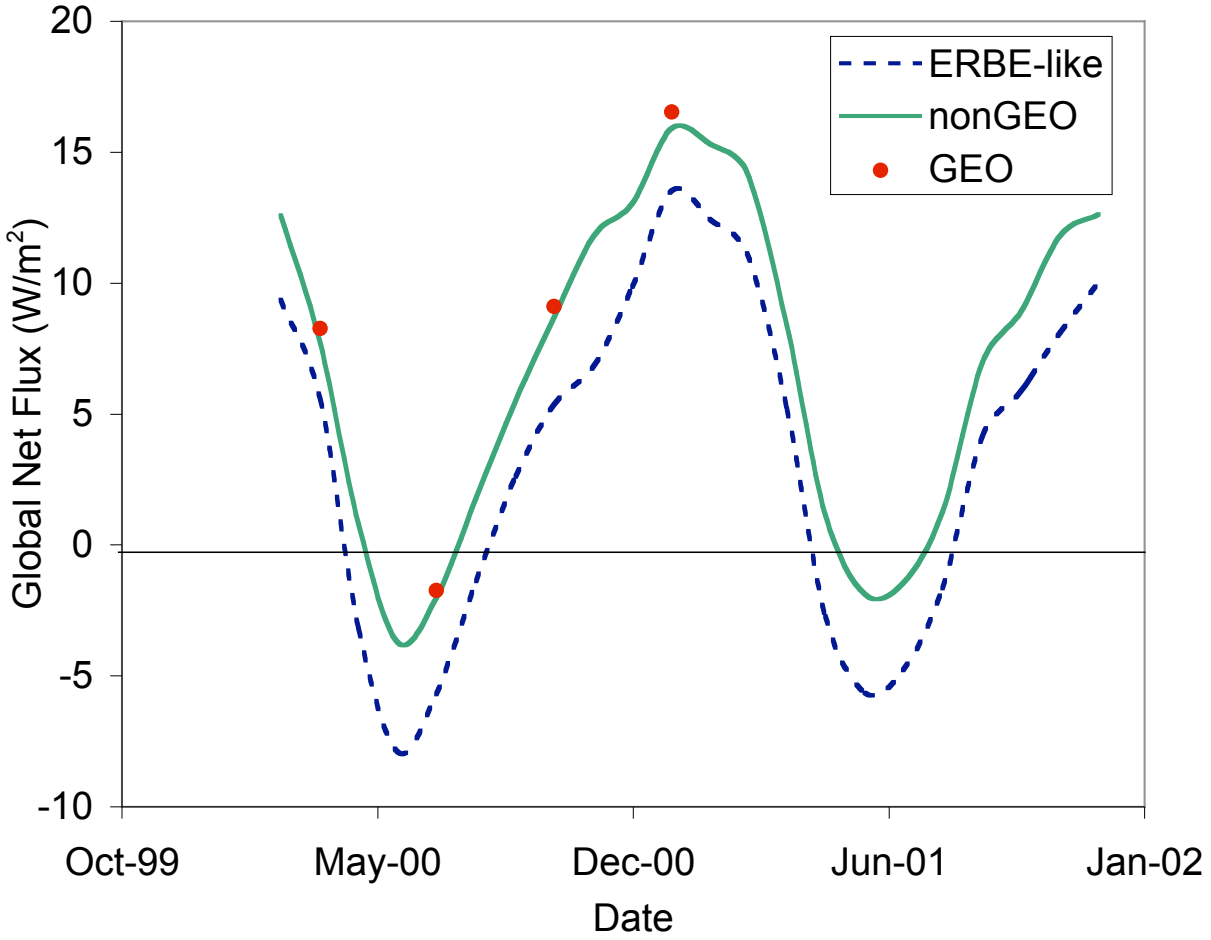
CERES Global Mean TOA LW Flux Comparison



CERES Global Mean TOA SW Flux Comparison



CERES Global Mean TOA Net Flux Comparison

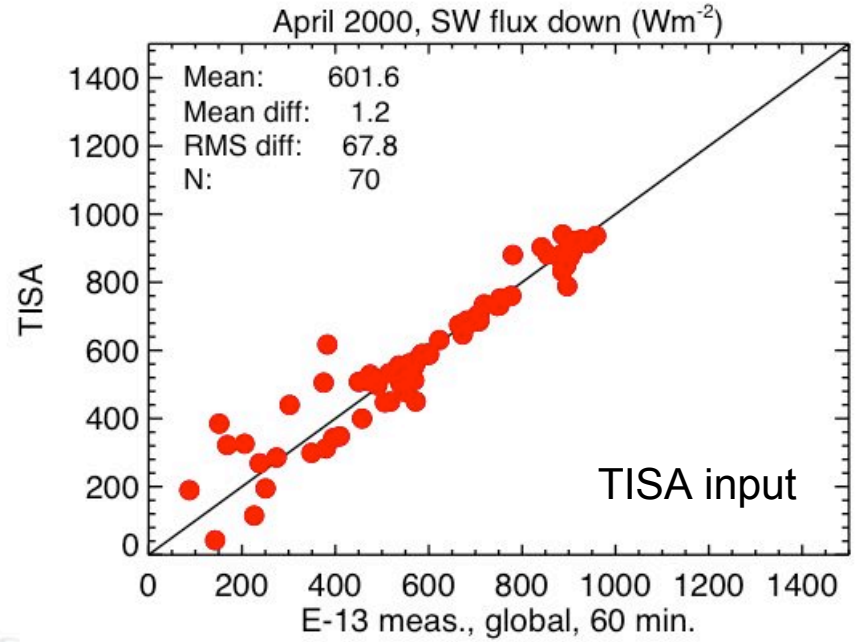


Validation
Comparisons with BSRN and SRB Surface Fluxes

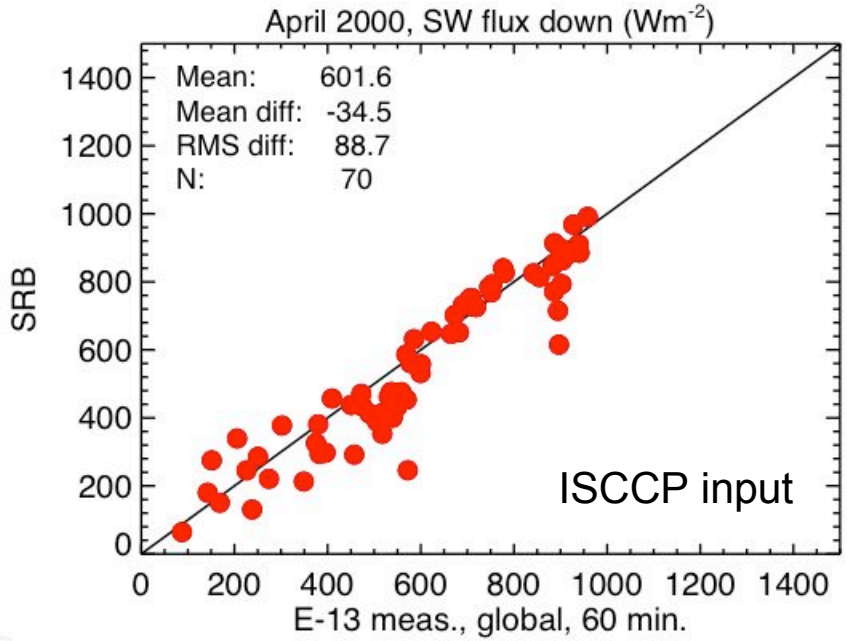
- Surface fluxes computed using TOA-Surface parameterizations
- Instantaneous comparisons with 60 minute-averaged surface data
- Monthly means also compared with SRB data
- Detailed SW comparisons will be shown by Hinkelman in Co-I report

Downwelling SW Surface Fluxes Instantaneous Comparisons at ARM SGP

CERES SRBAVG

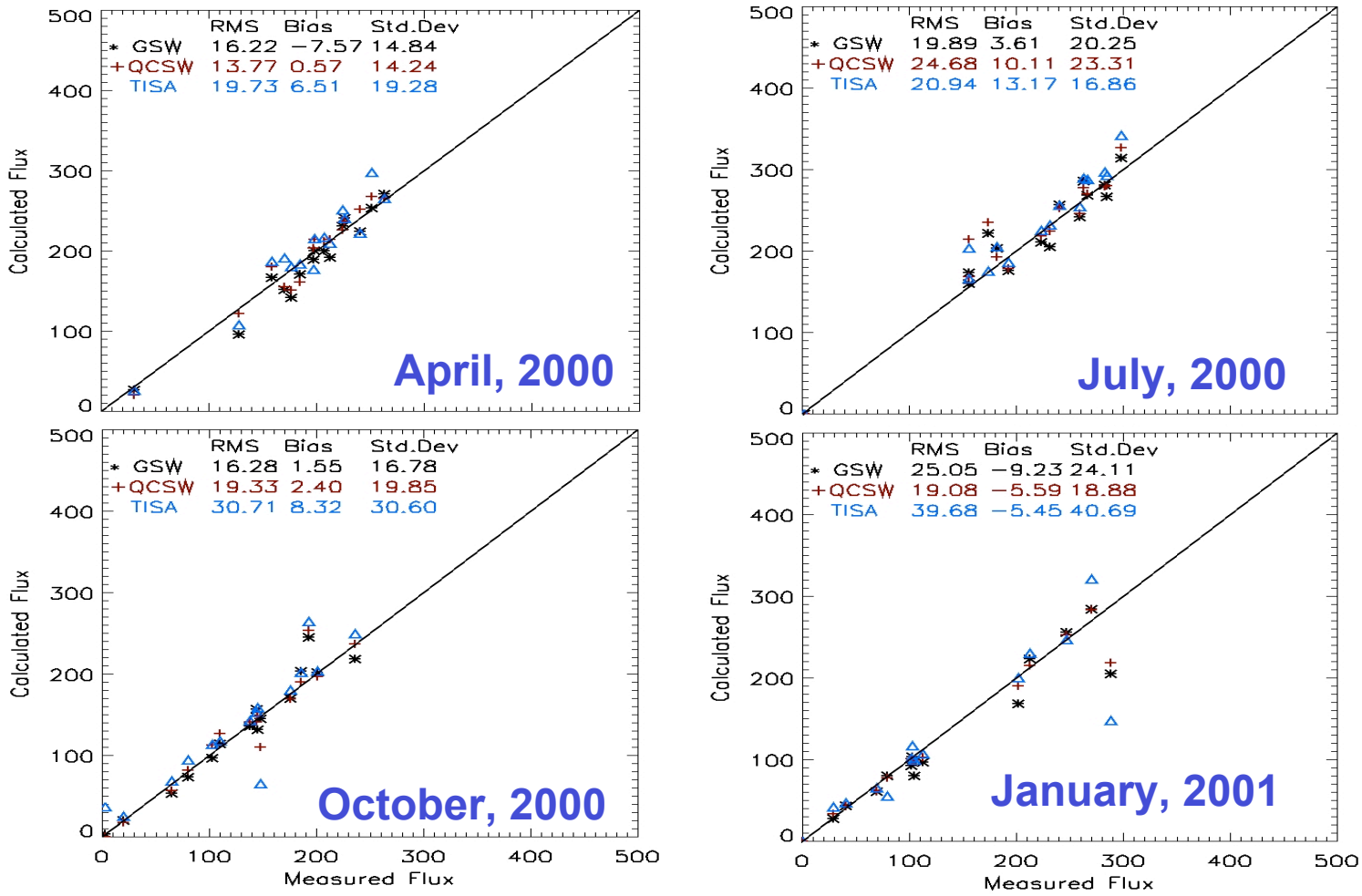


SRB



SRB and CERES SOFA TISA:
Downward Surface SW (with GEOS-4)

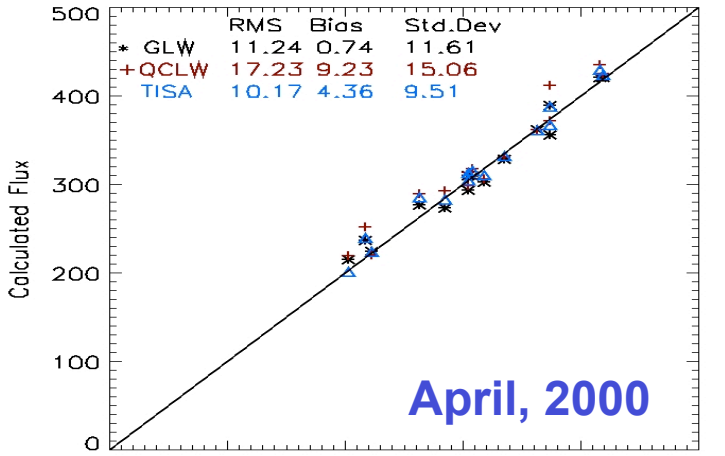
All BSRN sites, monthly results

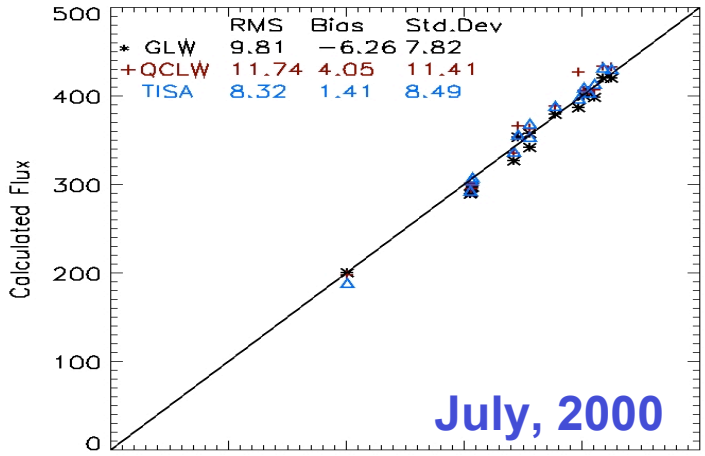


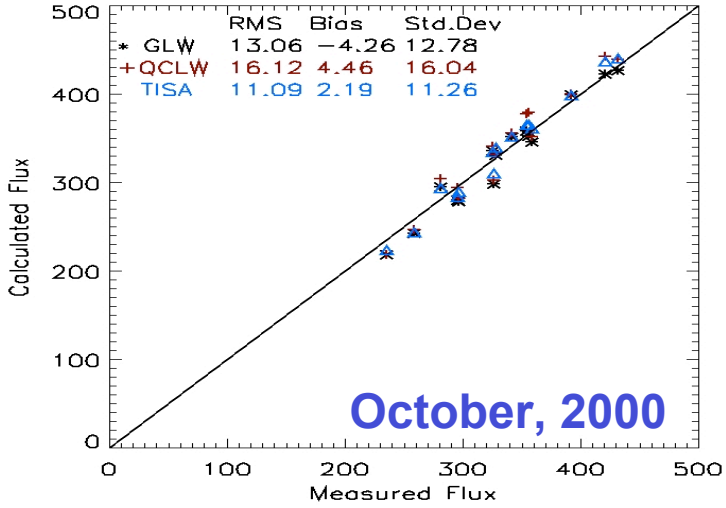
TISA
SRB
SRB+FU

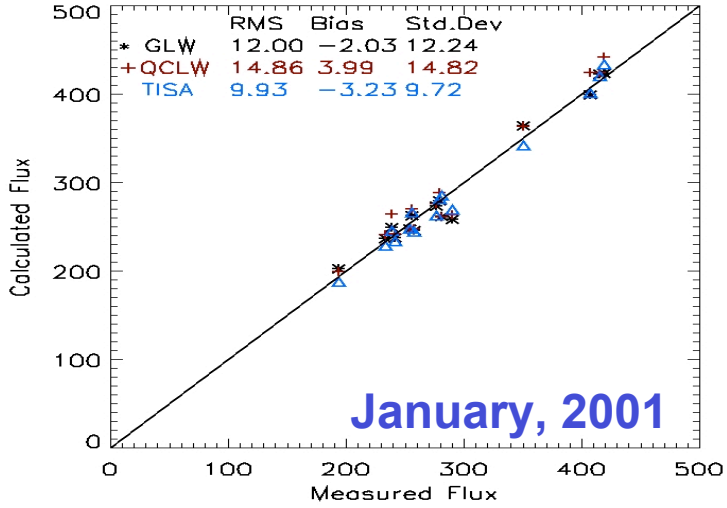
SRB and CERES SOFA TISA:
Downward Surface LW (with GEOS-4)

All BSRN sites, monthly results









TISA
SRB
SRB+FU

Major Issues

- Finish NB-BB
  - Figure out GGEO to MODIS spectral difference corrections
  - New model runs?
  - Redo calibration with spectral correction?
  - Linear fits are the baseline
  - Sza and cloud fraction functionality
  - O_3 and PW relationships
- Implement new normalization procedure
  - Normalizes both the clear and total sky
  - Clear-sky normalization needed to remove calibration offset errors
  - Must be flux based, GEO cloud property biases and misidentified scenes
  - Normalize to longer-term means instead of daily noise data
- Must reduce overall noise to climate accuracy level
  - Use monthly/spatially averaged means?

More Major Issues

- SYN/AVG not being actively worked
  - Should normalization be made using the unconstrained Fu Liou fluxes?
    - Logistically difficult
    - Depends on accurate cloud info instead of radiances
  - Do we need additional parameters?
  - Do we need to process TRMM?
  - Use SYN as a test for NB-BB?

Future Validation Activities

- Redo TRMM direct integration
- Perform extensive Terra/Aqua comparisons
  - Need new SFCs
  - Include hourly GGEO data
- Surface comparisons for 3 years of Terra data
  - BSRN and SRB
- Create DRM from GEO data + NB-BB
  - Waiting for finalized model
- Global net fluxes
  - ERBElike vs nonGEO
  - nonGEO vs GEO
- GERB comparison
  - April 2004 produced (is this useful?)

Possible Additions to SRBAVG
What should be the priority?

- Daily Means
  - Can be added as a separate SRBAVG file
  - Several requests already received
- Cloud type averages, based on optical depth and cloud height thresholds
  - Similar to ISCCP
- nonGEO (Fu-Liou derived) surface fluxes
  - Consistent with nonGEO TOA fluxes

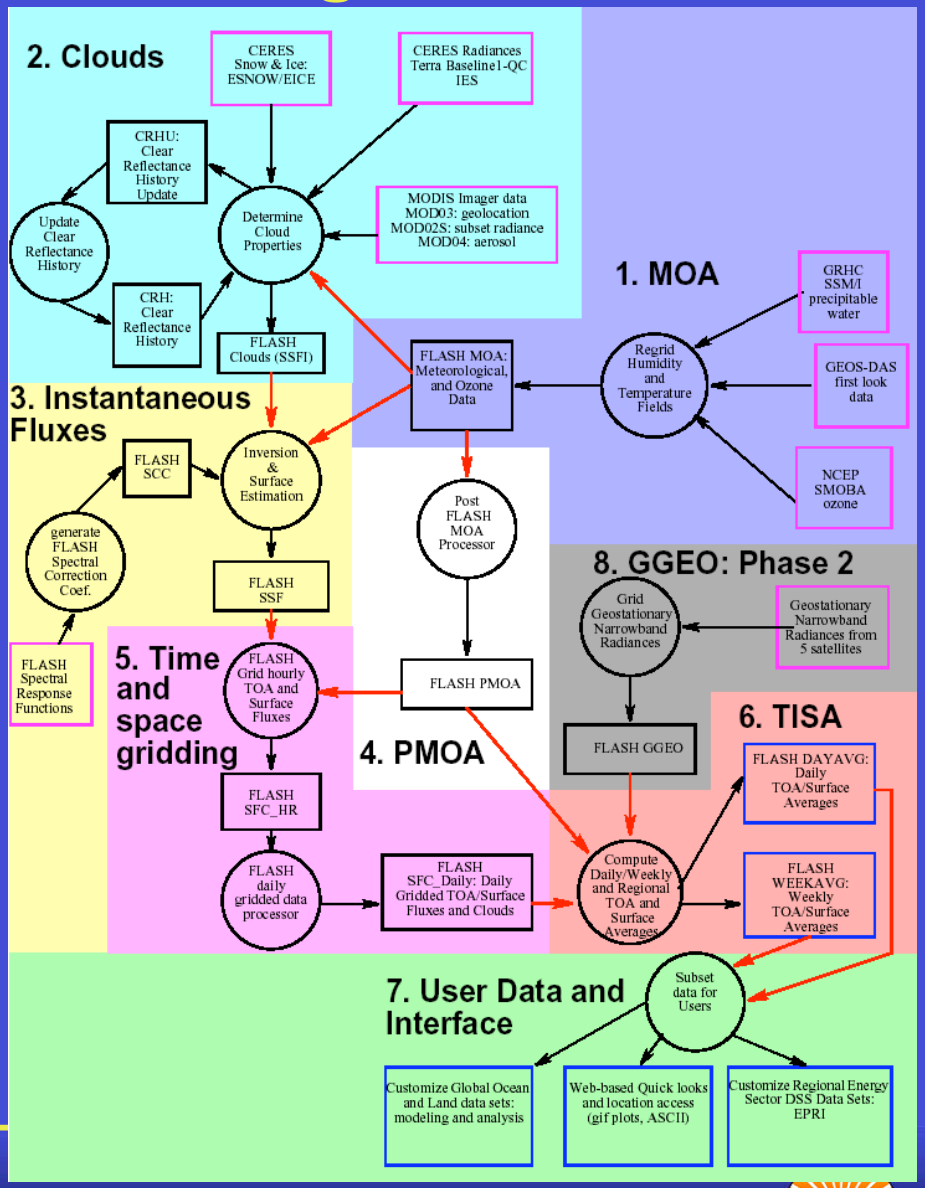
Back-ups

FLASHFlux Objectives

- **Objectives:**
  - Compute radiative fluxes from CERES observations within one week of measurement (for time averaged data within 1 week of last measurement)
  - Provide datasets to ocean (WHOI) & land (GSFC) assimilation teams
  - Provide datasets for CALIPSO and CloudSat
  - Use datasets for scientific evaluation of climate variability
  - Provide datasets to energy sector applications project POWER
- **Requirements:**
  - Design processing system for operational data production
  - System flexible to accommodate upgrades to input quantities (i.e., higher resolution reanalysis, geosynchronous data)
  - System must be operational within 12-15 months to accommodate science and applications guidelines.
    - Ocean assimilation modelers looking for flux datasets in 1-2 years
    - Applications reports to OMB require FY05 results

FLASHFlux Processing Plan

1. **CERES subsystems MOA, Clouds, and Instantaneous Fluxes and Inversion utilized with:**
   a. GEOS First Look analysis
   b. Latest CERES Calibration/Spectral Correction from Terra and Aqua
   c. Produce FLASHSSF as first official product
2. **FLASHFlux needs new TISA with 3-5 processing window**
3. **All processing at ASDC; modified Warlock configuration**



Key FLASHFlux Milestones

1. **Initial Processing Test (INTEX, 2004) (Nov/Dec 2004):**
   - Validation and verification of SSFi and SSF products

2. **FLASHFlux SSF Products from ASDC (Feb. 2005)**
   - Transition Subsystems 1–3 to operations and begin processing October 2004 ASDC

3. **Time and Space Gridding and Averaging Development (April/May 2005)**

4. **Data and User Interface: 2 months (Jun 1, 2005)**
   - **Woods Hole Institute (Ocean flux data assimilation)**
   - **CERES S'COOL**
   - **Other renewable energy interests and partners (i.e., NREL, EPRI, EPA)**

5. **Full Operational Testing – Phase 1 (July, 2005)**

McIDAS GEO Data Acquisition

- Currently we get GEO data from several sources
  - Data is 3 hourly
  - Different formats for each satellite
  - Data gaps and poor navigation are common
- Use McIDAS (Man computer Interactive Data Access System) to acquire GEO data
- McIDAS is a set of tools to acquire, manage, analyze, display, and integrate data (developed by Univ. Wisc-Madison's SSEC)

McIDAS GEO Data Acquisition

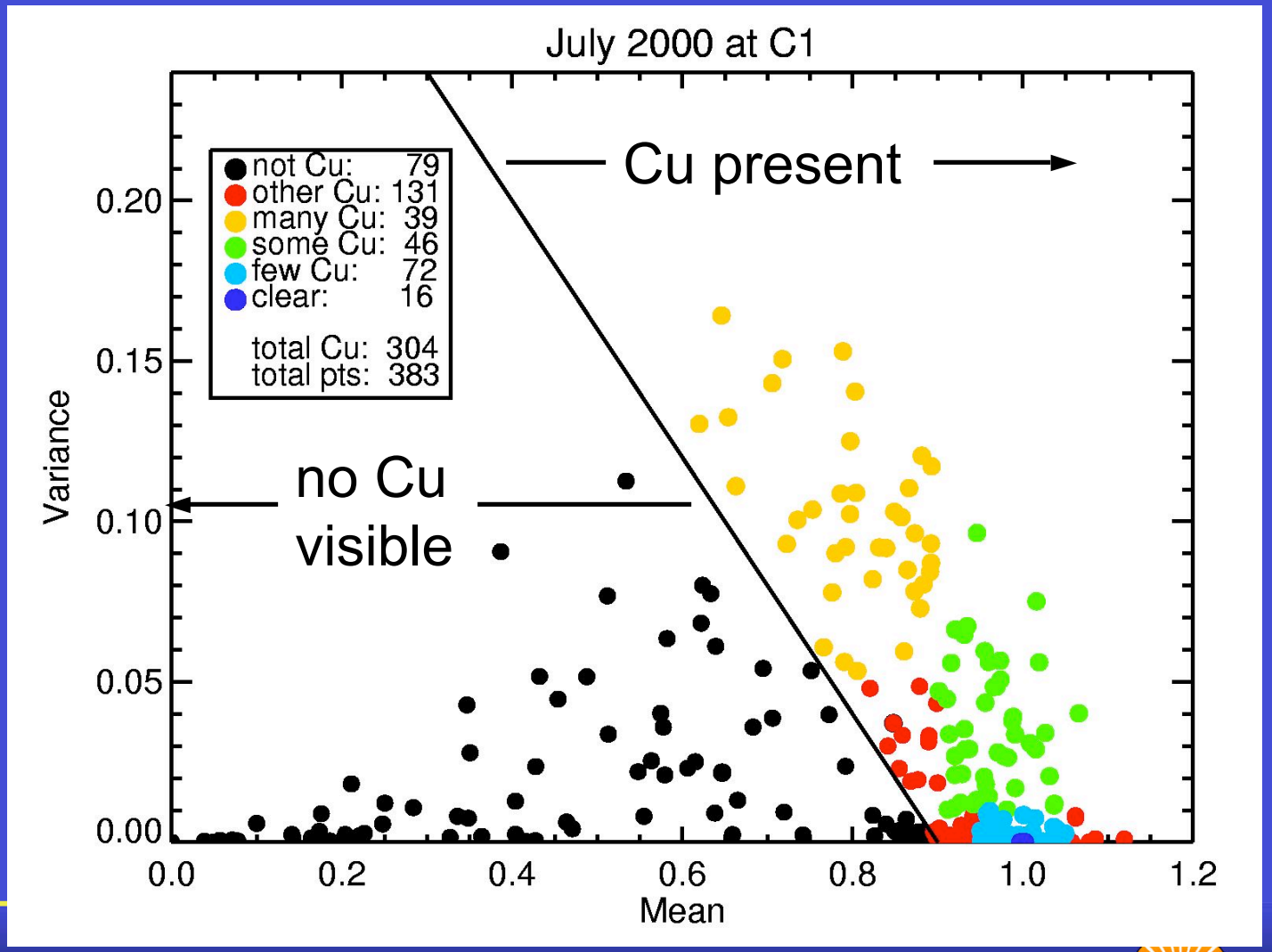
- McIDAS GEO data provides these benefits
  - Standardized formats
  - Data collected in near Real-time
  - All GEO satellites available including SEVERI
  - Solves navigation problems (i.e. GMS5)
  - Eliminates data gaps (order from Archive)
  - Improved calibration information
  - Provides new code for reading new GEO satellites (I.e. SEVERI)
  - Data is acquired 1-hourly at 8km resolution
  - Access to historical data

McIDAS GEO Data Acquisition

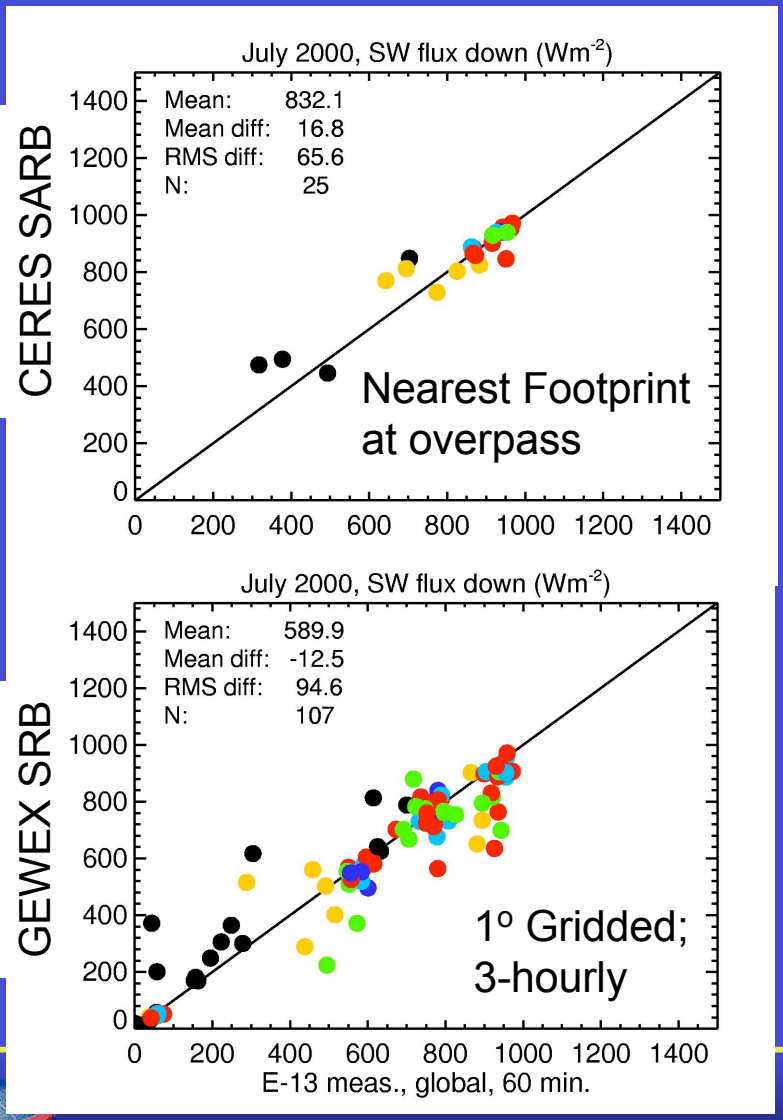
- Current Status of McIDAS GEO data
  - Operational data collecting scripts for GOES-E, GOES-W, GOES-9, MET-5, & MET-8 completed
  - McIDAS hourly data is currently being collected for all 5 GEO satellites since June 2004 (L. Nguyen)
  - Data collecting operations to be turned over the Langley DAAC by November 12, 2004
    - Testing phase
    - Operational by end of 2004
- Historical McIDAS GEO data needed to replace non-McIDAS data
  - Langley DAAC to order and archive data from Jan-Aug 1998 and Mar 2000 through May 2004

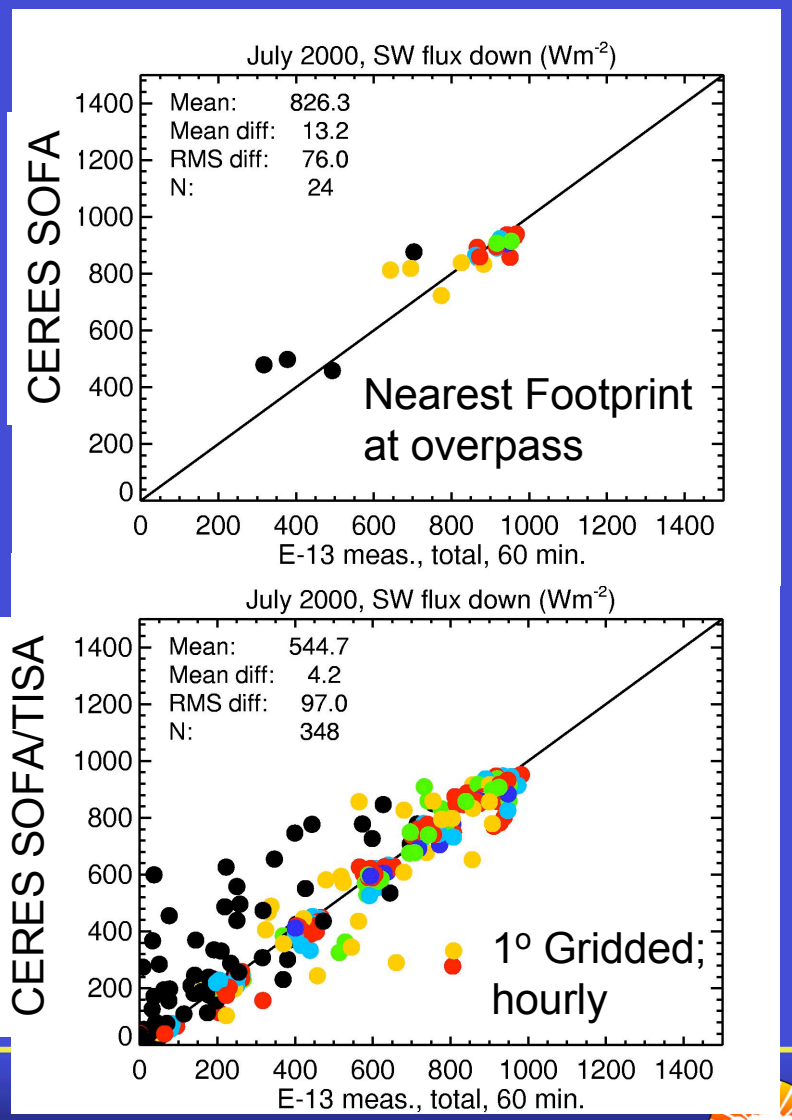
Instantaneous SW Validation:
Cloud Type (ARM CART site)

-Using Long/ Ackerman Clear-Sky Flux,
- Compute the ratio of the measured flux to the clear-sky flux
- Use the mean and variance of ratio to help separate cloud classes
- Compare separation to satellite images



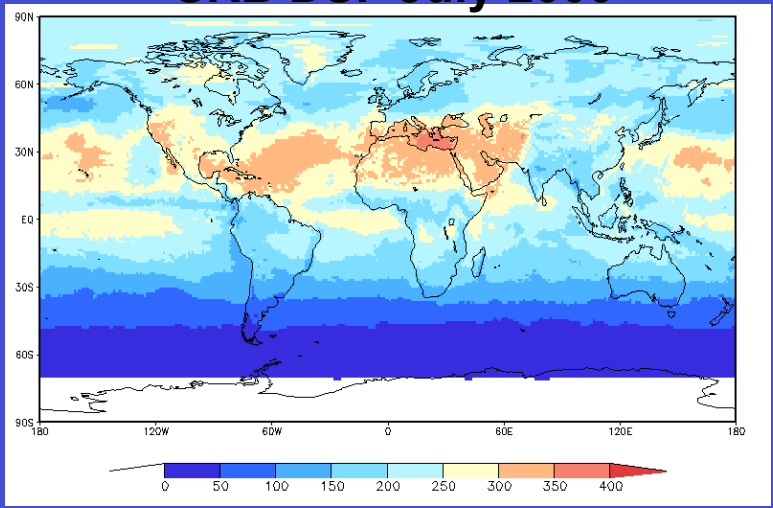
Instantaneous SW Validation:
SRB/CERES by Cloud Type Class



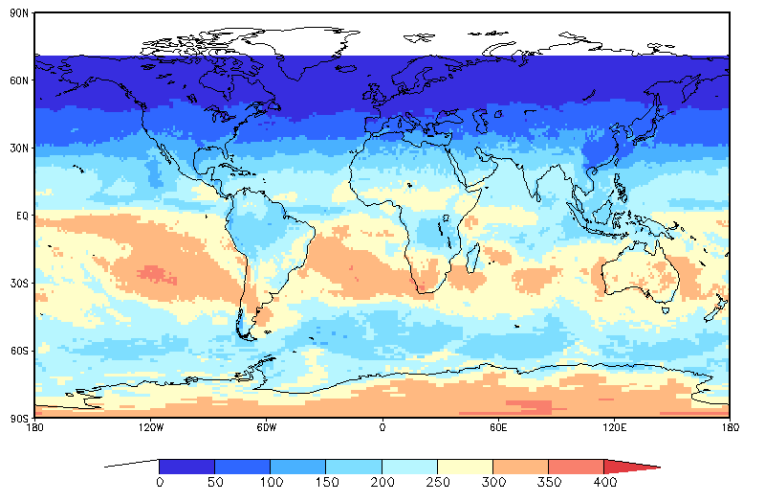


Monthly Averaged SW SRB/SOFA

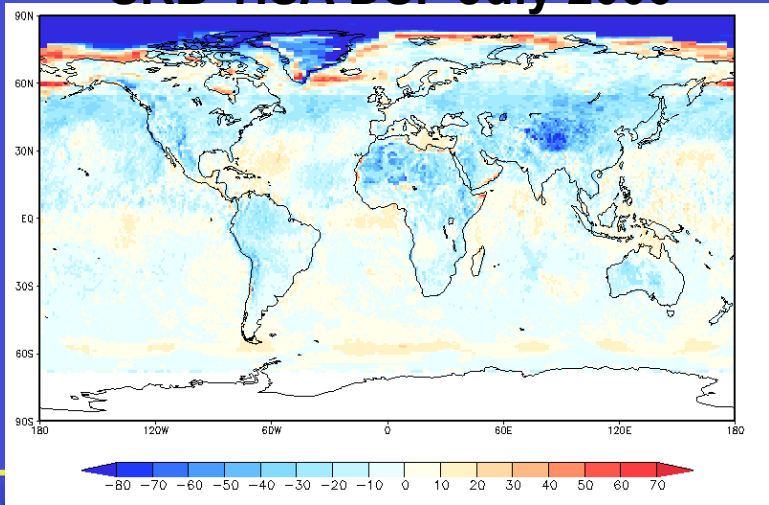
SRB DSF July 2000



SRB DSF Jan 2001



SRB-TISA DSF July 2000



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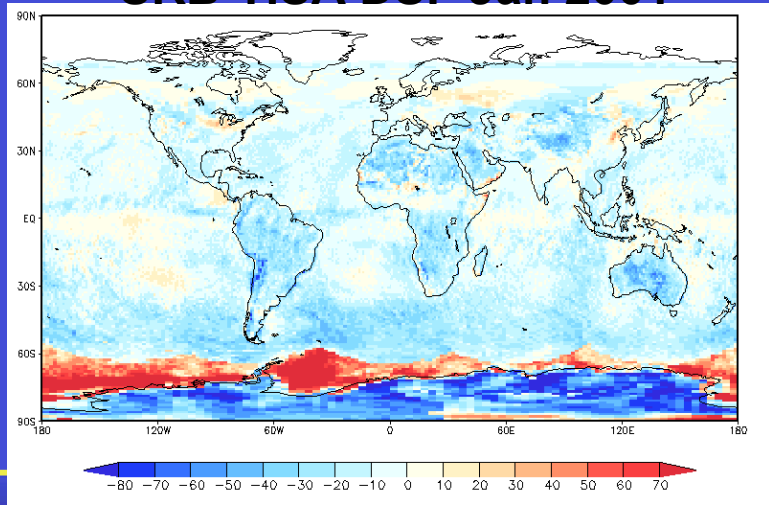
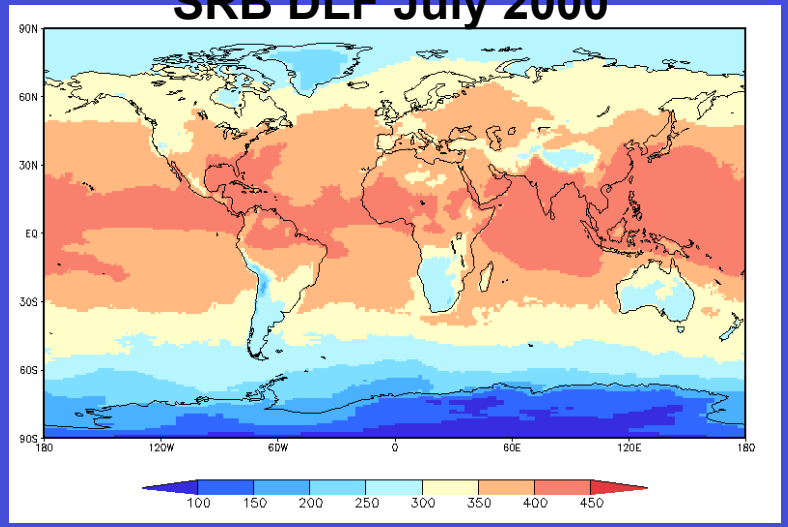
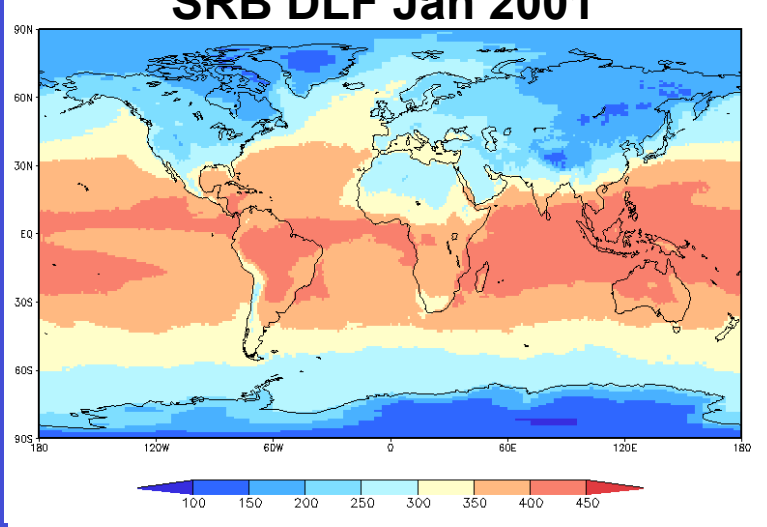


Monthly Averaged LW SRB/SOFA

SRB DLF July 2000



SRB DLF Jan 2001



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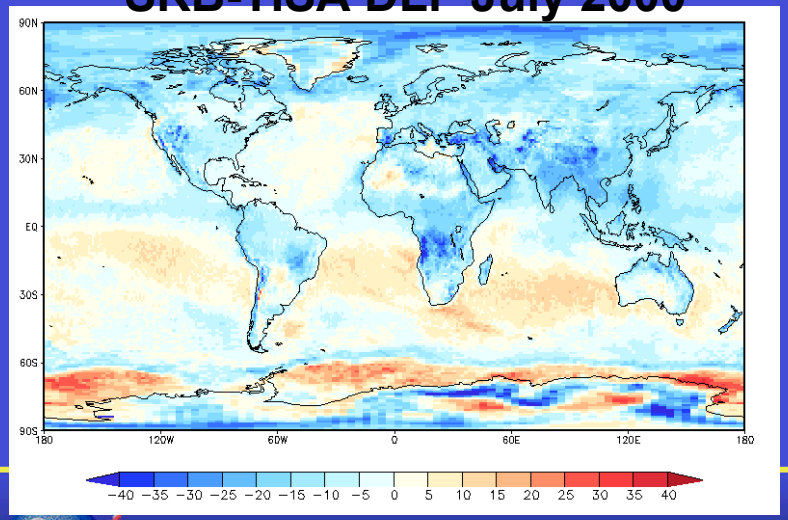

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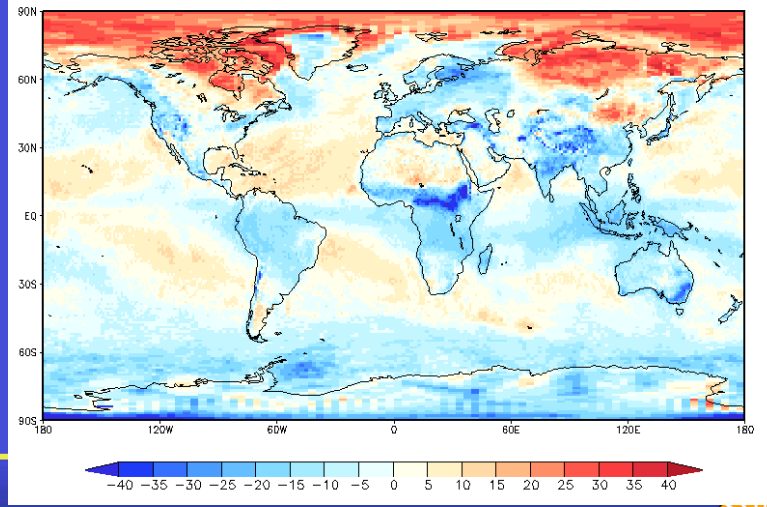
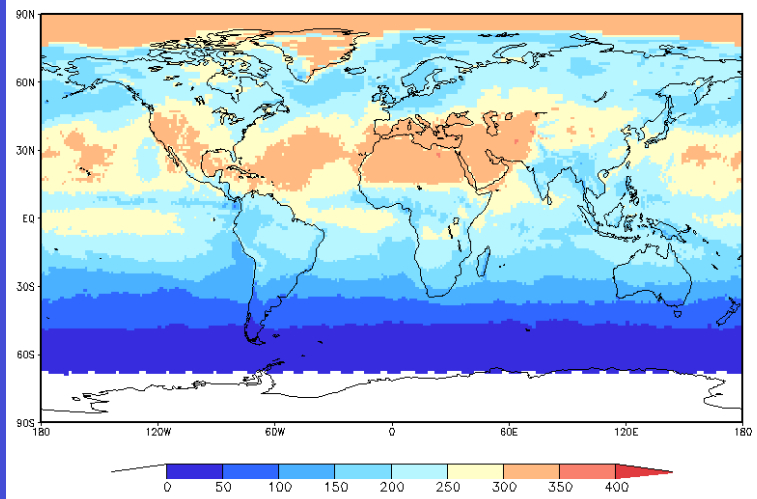
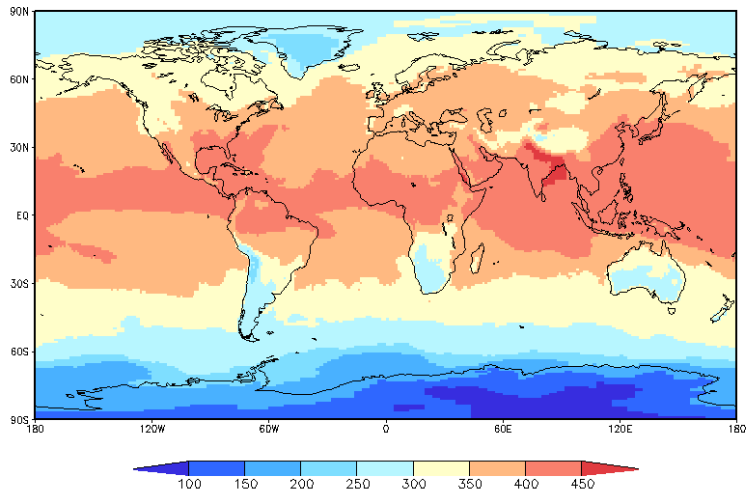


SOFA Model B/TISA SW Monthly Averages

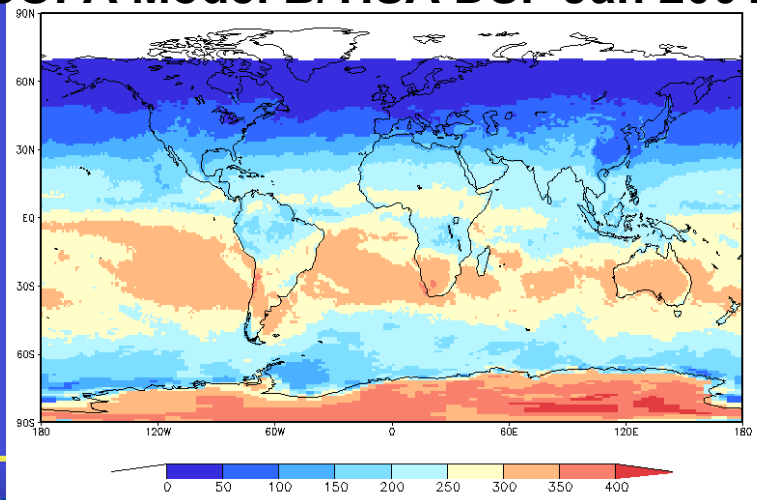
SOFA Model B/TISA DSF July 2000



SOFA Model B/TISA DLF July 2000



SOFA Model B/TISA DSF Jan 2001



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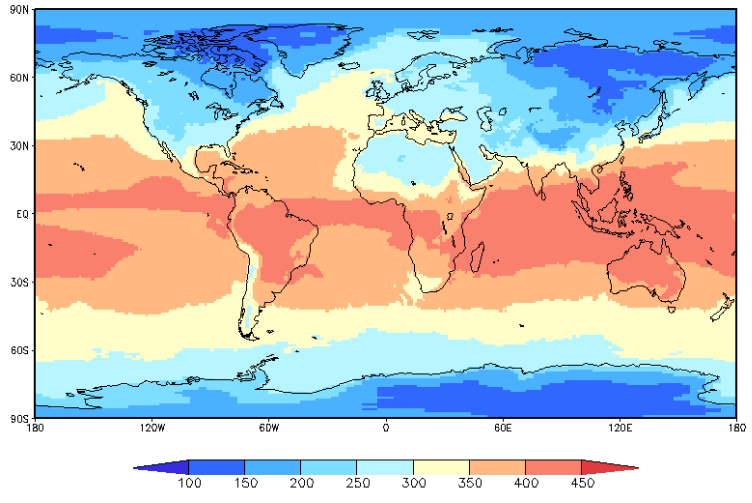
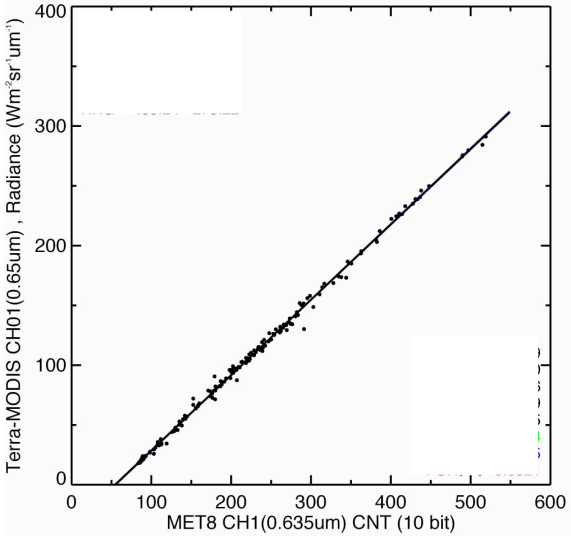


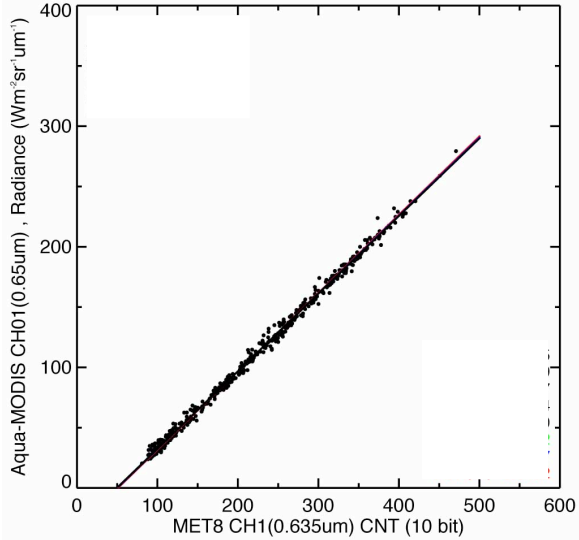
MET-8 visible gains, August 2004

Terra-MODIS



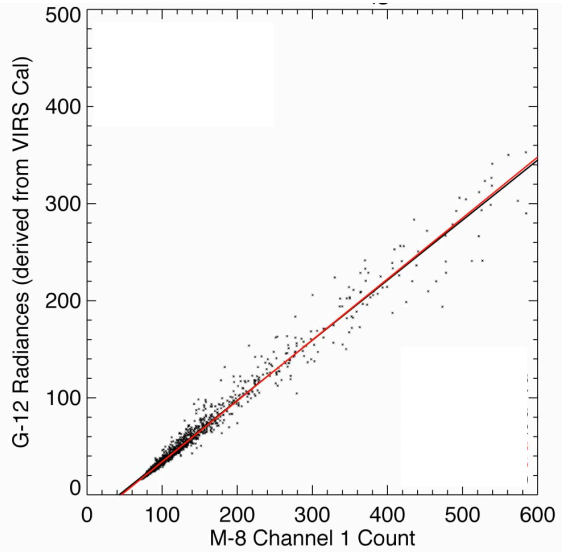
Gain 0.632

Aqua-MODIS



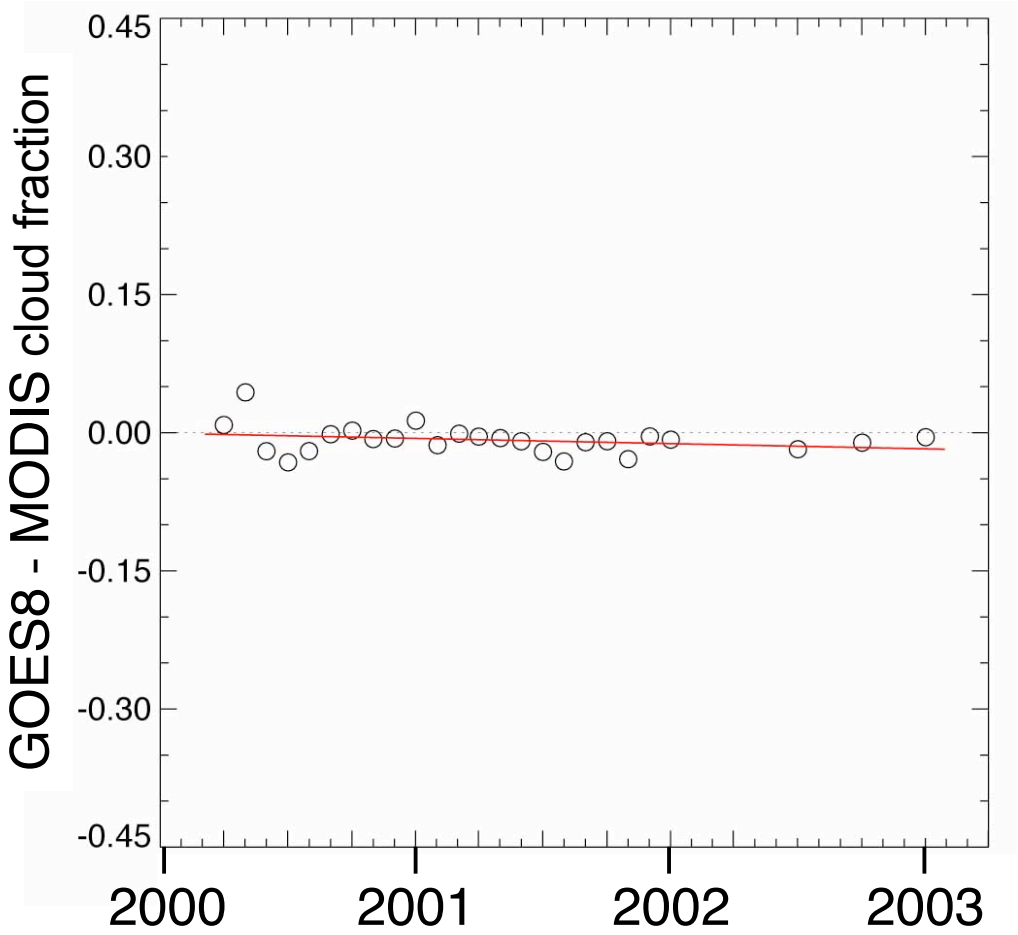
Gain 0.649

GOES-12



Gain 0.628

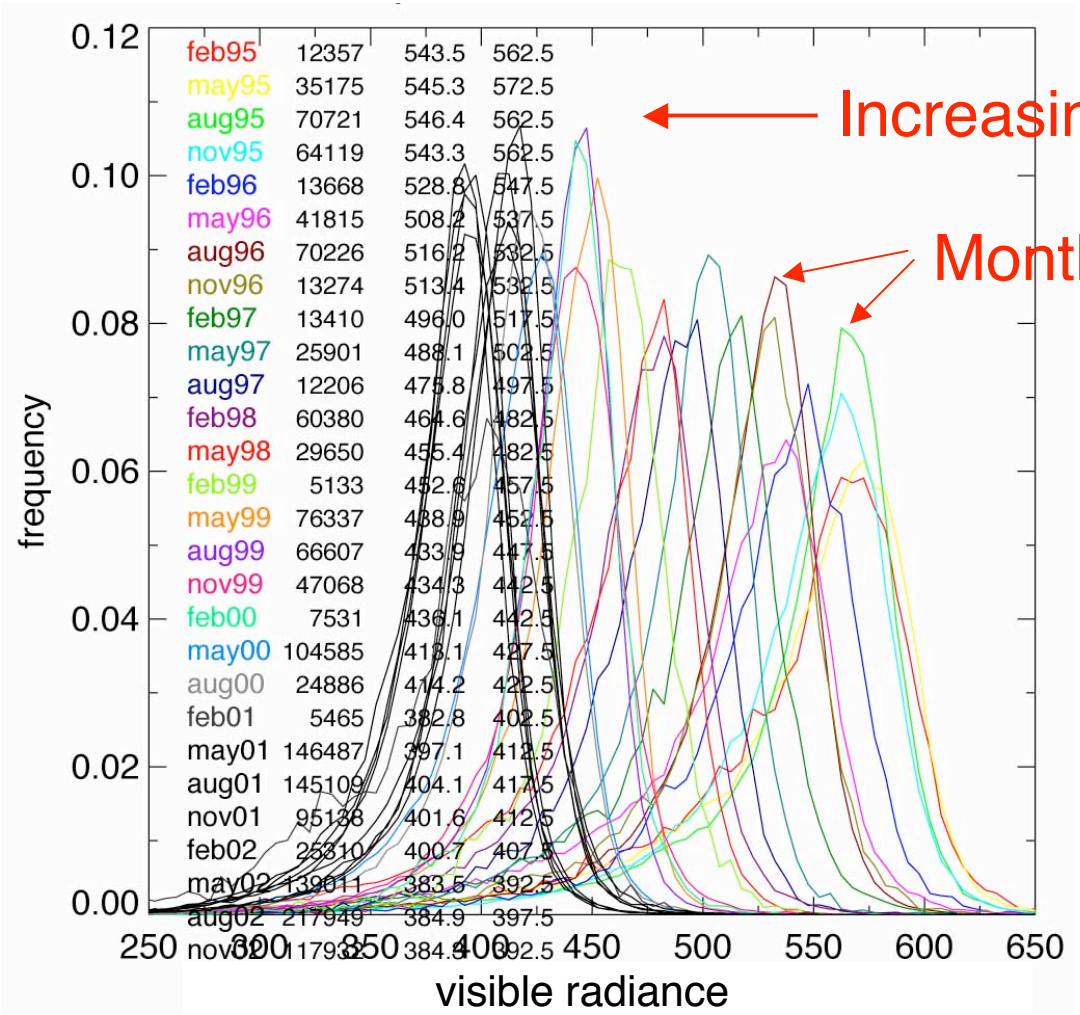
GOES8 - MODIS monthly mean cloud fractions



Deep Convective Cloud Calibration (DCCC)

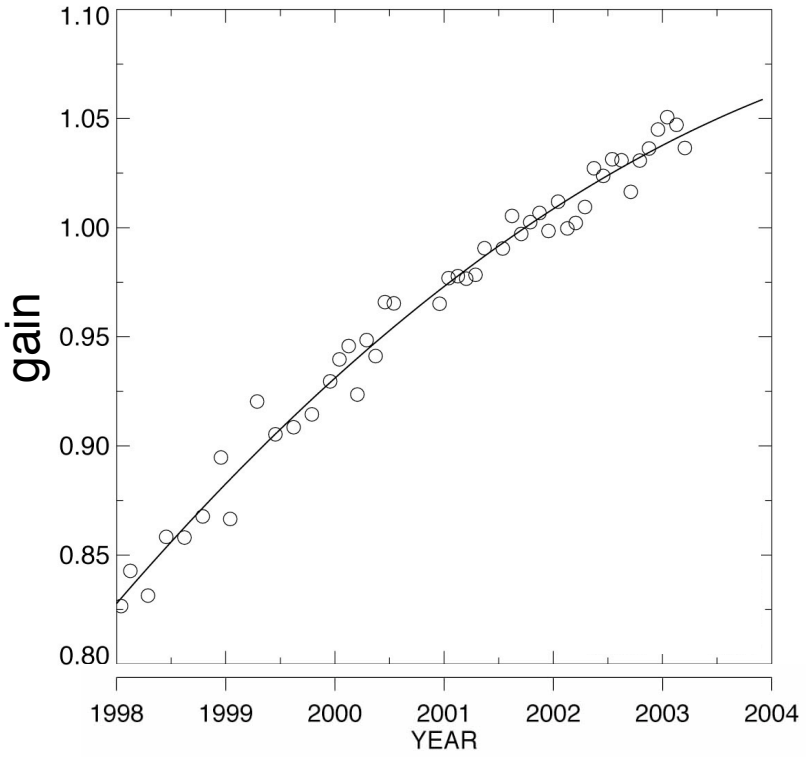
- Identify DCC pixel level radiances
  - IR threshold (< 205°K)
- Normalize to overhead sun
  - Hu bidirectional model
  - CERES directional model (ice cloud, @ 50 optical depth)
- Compute PDF from a months worth of pixel level visible radiances
  - 0.5% of area in tropics
- Plot the PDF mode as a function of time
  - Provides a relative calibration, not an absolute calibration

GOES-8 DCCC PDFs from 1995 to 2003



Validation of GOES-8/VIRS trend with DCCC

GOES-8 based on VIRS



GOES-8 based on DCCT